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ROBERT CRAWSHAY, OF CYFARTHFA.

THE INDUSTRIES OF SOUTH WALES.

No. II.

HAVING discussed in outline[1] the industries of South Wales, in the present paper we limit ourselves to the coal and iron which form its staple, and the present peculiar condition of the district. In the remarkable discussion about coal which took place some years ago the South Wales coal-field occupied a conspicuous position. Mr. Vivian, the member for Glamorganshire, asserted that South Wales could supply all England for five hundred years. This position was thoroughly scrutinized by Mr. Jevons in his celebrated work on the coal question. He considered that Mr. Vivian's statement was hardly worth criticism, and stated that the true question was, "How long will South Wales supply us at the present price with the present growing demand?" In the first place, however, it is desirable to ascertain the real coal measures of South Wales. So far back as the sixteenth century the coal-field was carefully surveyed over a hundred miles by a gentleman of Pembrokeshire, George Owen of Henllys. The manuscript slept in obscurity for more than two hundred years, when it was published by the great-grandson of the writer. Other efforts were made in other directions, but it was reserved for two deans of the English Church, Conybeare of Llandaff and Buckland of Westminster, to make full and accurate observations on this field in the "Geological Transactions." With the discovery of the mineral treasures mineral development has been constantly expanding. About one hundred years ago a "Geographical Description of Glamorganshire" was published, which closely reminds us of a celebrated chapter of a certain history of Iceland which was cited in Boswell's tour to the Hebrides with Dr. Johnson. The chapter was entitled, "Concerning Snakes," and ran as follows: "There are no snakes in Iceland." The writer of the Glamorganshire history makes the boast:—"Glamorganshire has no manufactures." I suppose that no statement was ever more completely falsified. The tendency of the practical engineers of Wales at the present time is to consider that Mr. Vivian's calculations, though so sharply criticized by Mr. Jevons, are very much within the mark. The thickness of the coal varies very much from valley to valley, but it is calculated that there is a *workable* produce of coal of 36,000,000,000 tons. The eminent engineer from whom we take this calculation adds:—"Great as is the quantity of coal comprised within this field, yet it has been wisely ordained of Him who hath done all things well, that the valuable mineral by the deeply denuded valleys intersecting the field, some of them 800 and 1000 feet deep, together with anticlinal lines and faults, have placed two-thirds of the coal, or that portion between the eastern outcrop at Pontypool and Blaenavon and the Vale of Neath, so that the lowest seam can be won by pits less than 1000 yards in depth." It has been proved in Belgium that coal can be worked to a still greater depth than this.

But while we accept with gratitude these more cheerful calculations, Mr. Jevons and his school have a solid basis of argument on their side. Mr. Smyth, the Inspector of Crown Mines, pointed out, several years ago, that the notable seam of house-coal, the Mynydd Isslwyn, has already been worked out over a great part of its area, and that large tracts of the best seam of steam-coal, the Aberdare four-foot, have already been exhausted. As nations become more civilized the demand for coal becomes more incessant. It is remarkable that the more the coal resources of foreign nations are developed the heavier becomes their demand upon the British market. But to use Mr. Jevons' oft-quoted words, "We are drawing more and more upon a capital which yields no annual interest, but once turned to light and heat and force, is gone for ever into space." It is only since the beginning of the century that men have found out that coal is "bottled sunshine," and have reconverted it into light. Murdock, Boulton and Watt's engineer, used to carry a bag of gas under his arm with a lighted jet before, to light him on his way home over the Cornish downs, and he would now and then frighten the superstitious miners by squeezing his bag and projecting a fiery tongue of flame. Since that time all our cities are lighted with gas, and fresh applications of coal are constantly being discovered. Since Mr. Jevons wrote, the price of coal has increased probably far beyond his calculation. The moral and social difficulties of the question have reached a height on which he perhaps hardly speculated. We do not know whether the sinful waste in the mines, and the annual slaughter of nearly a thousand lives, has materially diminished. Moreover, we constantly hear the assertion that the age of steam is only yet in its infancy, and we hardly know, except in the illimitable fields of North America, where its adult support is to be derived. The main difficulties of the present moment, however, are moral and social; our own workmen, by their restlessness and constant inclination to strike, are a dead-weight against their own interests and their own nation.

I have been making some visits of observation lately, and thought of calling my observations "South Wales after the Storm." Perhaps we obtain a better view of a district before or after a storm than when the storm is actually raging. I am sorry to say that there is a heavy groundswell left by the tempest of the recent strike, and some well-informed people think that it is not unlikely that it will recommence. The result of the recent strike may be briefly said to be that the men were victorious all along the line. Some attempts have been made to obscure and disguise the fact, but it is nowhere seriously denied that the men won the battle. To save a point of honour, and to leave the masters with their colours flying, the men nominally went back for a week or two, on the ten per cent. reduction made by the ironmasters. But during that week or so very little work was done, and that little consisted in getting things into order for recommencing on the full wages. Since that time the ironmasters have given a further advance of ten per cent., establishing a total advance of twenty per cent. on the terms which they were willing to give in the winter. If the general improvement in business could have been anticipated the strike would not have happened. I should be glad if this could be regarded as a satisfactory and abiding settlement for some time to come of all matters in dispute. But I am afraid that there is a great deal of unrest and dissatisfaction on the part both of masters and men. The immediate rock ahead is the new system of weighing according to the Mines Act which comes into operation on the 1st of August.

The delegates of the colliers are rapturously in favour of the imperial weight of the realm being applied to the weighing of coal, with the evident desire that the present price given for the customary weight be transferred to the standard ton. The masters as vehemently object to this latter clause. They say that the difference between the 2,000 lbs. and the 2,520 lbs. is a most serious one, and amounts to a very heavy increase of wages. Their contention is that 2,520 lbs. which they receive from their men represent no more than the ton of 2,000 lbs. which they rate the public, the difference disappearing in various ways,—loss during transit, admixture of shale or stone, and in the weighing process, when a large quantity which has been weighed altogether at the outcome is reweighed eventually in hundreds of parcels, each parcel having a little overweight in order to make good weight, which amounts, in the total, to a serious deficit. I have even heard an owner say that he must close his pits unless some balance is found against the altered system of weighing. I also hear a great deal just now of combination among the masters. But a trade union of masters has seldom the force and coherence of a trade union of men. It is difficult to bring them to an agreement, and still more difficult to make them abide by the agreement they have made. There is an immense difference in interests and localities; and the contracting parties would range from millionnaires to adventurous beginners very little better off than viewers. The past is hardly encouraging for any process of lock-out; but the best friends of the men begin to fear that they may push their advantage too far, and peril some of the results they have gained. It is almost hopeless to attempt to arbitrate between the conflicting views and statements of workmen and owners. I had a long conversation with a colliery proprietor lately who pays away some two thousand pounds a fortnight in wages. He says that his class are distinctly poorer now than they were some years ago; that while they give double pay, they do not get half the output of coal that they did some years ago. For his own part, he would be willing to sell all his shares in coal-mines for half the price he had paid for them. The profits in coal mainly fell to the middleman, the broker who bought and sold the coal in the docks of the seaboard. I suggested that as the rails ran straight down from the valleys to wharfs, the services of the middleman might be dispensed with, and the owner might obtain direct profits. He replied that efforts had been made to break through the monopoly, but they had always been unsuccessful. The conduct of the colliers was thoughtless in the extreme, injurious both to themselves and the owners. His men were taking a holiday for two or three days because they were discussing internal affairs. The proprietors represented to them that it would be far better that they should do a day or half a day's work, and attend to their business afterwards; but this the men were unwilling to do. All this time the current expenses of the pits were going on as usual.

An improvement is reported in this respect in the Merthyr district since the last strike. Formerly, when thirty furnaces were burning, a dozen would be utterly wasted, there being no

[1] Vol. i. p. 199.

men to work them. The district between Treforest and Lantwit appears to me to be in the least satisfactory position. Here most of the old complaints alleged against the colliers cannot be much modified. Moreover, the union rules are enforced with the greatest rigour. The colliers are all Welsh, nor would Irish and English be allowed to work. Every collier must be a union man. Nobody will be admitted unless he is the son of a collier. In this district it is openly said that no settlement has been arrived at, and the chances of an early strike are openly discussed.

The capital of the coal and iron district is Merthyr Tydvil. The district has a population of 50,000, living in 10,000 tenements. The strata of coal are of excellent quality, accompanied by parallel veins of iron ore. Any one wishing to study this complex subject must study the town and its environs. When the papers were last busily describing the district there was, with insignificant exceptions, a cessation of business. The wintry snows and storms harmonized too well with the desolate appearance of the town and the stagnation of its industries. Now there are cheerful suns and warm days, shops and markets are in full activity, and the working men in their thousands are rejoicing. I am glad to believe that the worst features of the strike were somewhat exaggerated at the time. There were only two small failures among all the tradesmen. Many more persons obtained work in other districts than is popularly supposed. They might be seen returning to their wives and families on the Saturday nights with the wages they had won. The union gave a measure of support, not sufficient indeed, but certainly better than nothing, a sum that was considerable in itself. The men who were respectable and could be trusted got heavily into debt, but they are now fast emerging from it. Many are the signs of returning prosperity, some of them not of the happiest augury. The charges for drunkenness, which were almost *nil* during the strike—the general good behaviour of the men elicited universal admiration—have been mounting up considerably. There was an enthusiasm for Good Templarism, which was very striking and promised to do great things, but after a few weeks various Good Templars underwent a moral relapse. I have been listening for a time to a murder trial at the Glamorganshire assizes, which gives a sad view of the drunkenness and violence that may be found at Merthyr Tydvil, though of course it would be obviously unfair to generalize from this special case. At the same time, when we compare Sir Thomas Philips's book written a quarter of a century ago—he was an ardent Welshman and wished to put his countrymen in the best light—we perceive that Merthyr Tydvil has made a great advance.

I had heard a great deal of the somewhat peculiar condition of things at the Cyfarthfa works; I had even heard the term "paternal relation" of the employers towards the employed at Cyfarthfa, and intended to give the matter a detailed examination. The Cyfarthfa works are by no means so large as the Dowlais, but they are larger than the Plymouth, and are very accessible, being hardly a mile from the town. They employ altogether, men, women and children, close upon five thousand people. I suppose that at the present time it would unquestionably be more profitable to the owners to sell the coal at the present enormous prices than to use it up for iron. The profits on coal are enormous, if the profits really come to the owners, but iron shows extremely little profit. The plant, however, being in existence, the traditions of the firm having to be maintained, some sort of vested interest being allowed to the employed, some hope of better times being indulged, the iron-works at Cyfarthfa are continued, and probably would be even with a positive margin of loss. Some coal is sent from Cyfarthfa, but iron mainly. There is certainly a sort of ancestral and patriarchal feeling at Cyfarthfa which hardly exists elsewhere. There are many men who have grown grey in the employment of the Crawshays, who have never changed or would wish to change their place. They have begun as children, perhaps only fetching and carrying small articles, for a few shillings a week, and have gone on to earn, as firemen and puddlers, their three pounds. There is not the same intense pressure to produce here as in other districts. The owner, having inherited "a few loose millions," can afford to take things considerately and calmly. If you take the manager of a company, with his five thousand a year salary, and wanting to make another five thousand a year by his commission and percentage, you have, of course, a very different set of circumstances; he is anxious to produce as fast as possible, but the owner of Cyfarthfa is reported to have once truly said that he could afford to shut up his works for fifty years.

The Crawshays have always shown a strong individualism of their own, as thoroughly able and independent, straightforward and liberal men. Bishop Watson, an absentee bishop, who only came into his diocese once in three years, in his curious "Anecdotes of his Times," says, "I went over the mountains from Neath to a place where no bishop had ever held a confirmation before, Merthyr Tidvil. I was, whilst there, hospitably entertained and lodged by Mr. Crawshay, one of the most intelligent and opulent iron masters in Europe." He goes on to relate that Mr. Crawshay said that there would always be three or four thousand pounds at his service if he happened to want them. It was a greater civility than the absentee prelate deserved. At the pits and works Crawshay follows Crawshay. "An Amurath to an Amurath succeeds." Mr. Richard Crawshay, in 1847, when entertained at dinner by the people of Merthyr, gave an account of the rise of his family of "iron-kings." "My grandfather was the son of a most respectable farmer in Normanton, Yorkshire. At the age of fifteen father and son differed. My grandfather, an enterprising boy, rode his own pony to London, then an arduous task of some fifteen or twenty days' travelling. On getting there he found himself perfectly destitute of friends. He sold his pony for £15; and during the time that the proceeds of the pony kept him he found employment in an iron warehouse in London, kept by Mr. Bicklewill. He hired himself for three years for £15, the price of the pony. His occupation was to clean the counting-house, to put the desks in order, and to do anything else that he was told. By industry, integrity, and perseverance he gained his master's favour, and was termed 'The Yorkshire Boy.' He had a very amiable and good master, and before he had been two years in his place stood high in his master's confidence. The trade in which he was engaged was only a cast-iron warehouse; and his master assigned to him, the Yorkshire Boy, the privilege of selling flat-irons—the things with which our shirts and clothes are flattened. The washerwomen of London were sharp folk, and when they bought one flat-iron they stole two. Mr. Bicklewill thought that the best person to cope with them would be a man working for his own interest, and a Yorkshireman at the same time. This was the first matter of trading that ever my grandfather embarked in. By honesty and perseverance he continued to grow in favour. His master retired in a few years and left my grandfather in possession of his cast-iron business in London, which was carried on on the very site where he ended his days—in York Road. My grandfather left his business in London and came down here; and my father, who carried it on, supplied him with money almost as fast as he spent it here, but not quite so fast. What occurred subsequently this company knows perfectly well. Who started with humbler prospects in life than my grandfather? No man in this room is so poor but that he cannot command £15. Depend upon it that any man who is industrious, honest and persevering, will be respected in any class of life he may move in. Do you think, gentlemen, there is a man in England prouder than I am? What is all the world to me unless they know me?"

I was certainly somewhat disappointed with my experience of the Castle. It is a somewhat imposing structure of grey stone, but by no means so extensive as I had been informed. I had heard a story at a London club of the elder Crawshay, now "gone over to the majority." He had asked for some carpeting at a west-end shop, but had not been satisfied with what he had seen. The shopman began to look with a little contempt at the homely figure before him. "I suppose," he said at last, "that what you really want is some remnants." "They must be biggish remnants," quietly answered he of Cyfarthfa, to the astonished shopman, "to cover seven acres." The story is *ben trovato*, so good as to be good for nothing. The castle edifice stands upon about half an acre of ground. The grounds are large, the gardens extremely good, the park somewhat extensive, without deer, but with plantations well preserved for game. It is quite unlike any castle that I have ever seen or stayed at. It has a stern, utilitarian character, peculiarly its own—the lodge gates facing the grimy lane that goes down to the grimy works.

Coming out on the terrace the unique character of the stern, rough place, fit residence for an iron king, impresses you strongly. Some iron rails, a kind of tramway, come almost to the front door. The place might be a fortress, a mill, a lunatic asylum, unless you knew to the contrary. A somewhat steep ascent leads you to the gardens behind the house, with conservatories and ferneries. Some of the hothouses are very rich in their contents. The flowers might be the glory of any conservatory, but even in looking at the flowers you could not get rid of the idea of iron and coal.

I did not see the works in operation, as it was a Saturday afternoon. The workpeople take holidays whenever they like, but the establishment closes up for a half holiday on Saturday afternoon. People were still coming to be paid, though the afternoon was very far advanced. Might it not be better, however, to take the Friday afternoon as pay-day? I did not mind the non-working, as I had seen the Dowlais works at the very best time for seeing them, at midnight and the small wee hours. I shall never forget the ghostly forms of the naked men

passing to and fro before the lurid furnaces. Several points about the Cyfarthfa establishment struck me as being extremely satisfactory. There is a charge of a penny in the pound for medical advice and attendance. The charge could not, I think, be smaller, and must be supplemented, I should think, by Mr. Crawshay. There are good schools, irrespective of any school-boards, but under Government inspection, and here the fixed charge on earnings is one halfpenny in the pound. I have heard of other works where men have refused to pay the half-penny, and the schools have been shut up. I asked about house accommodation, but was told that nothing was done in this respect, and that this was left to the efforts of the men themselves. I am glad to observe that at Mountain Ash the men, since the strike, are devising a co-operative system for building houses for themselves. I am told, however, that the great proprietors are the owners of a good deal of house property, and I should be glad to know in what condition the house property is. I am informed on the highest authority that there is a great deal of consumption in Merthyr Tydvil, on account of the dampness of the walls and floors of the lower rooms. The wages paid are immense. I heard of none less than thirty shillings a week, and there are firemen and puddlers making their four pounds. If they choose to absent themselves, their leisure would be wisely laid out in mental improvement or physical recreation. I know of a father and sons obtaining twenty-seven shillings daily. A father and some sons combining might secure a competence, save money, obtain occasional leisure, and live like professional people. For the present, I am afraid that this is little more than a dream. The energy and the moral power are wanting. You may see hundreds of men sitting about the high roads smoking, without the slightest idea of utilizing or enjoying the holidays they are giving themselves. All around Merthyr the country is one of much grandeur and loveliness. But there is not the slightest idea of ruralizing, and thereby storing up energy and health. The holiday becomes deleterious rather than healthy. There is probably no subject on which the workman's mind is busier just now than the rights and wrongs of his order. There seemed to me a good deal of unrest about them, the groundswell after a storm, or perhaps the stirring up of the elements; and I am afraid it is among the possibilities that there may be another storm, not far in the future. The collier reckons a great deal on what he shall get for that sevenpence a month which he pays to the union. His mind seems always fixed upon the chances of a rise. He forgets that if his wages rise all prices rise at the same time, and that his nominal gain therefore requires a considerable reduction. He seems to be any moment ready for a strike or an agitation. There appeared to me to be a deepening and broadening of the antagonism of classes as the result of the recent storm. I witnessed a paying day, and I did not like the cold, mechanical way in which the men took their wages, without a touch of gratitude or kindly feeling, evidencing the antagonism of classes. I spoke to one or two men about the union, and they struck me as possessing all the acuteness and resolution which any such society could desire its members to possess. Their tone impressed me as being feverish and unhealthy. On the whole, I shall be glad to find that the new weighing system comes into operation in August without any derangement of the *status quo* in South Wales.

THEATRES.

By EYRE M. SHAW, *Chief Officer of the London Fire Brigade.*

THE singular immunity from loss of life which has of late years attended the destruction by fire of theatres and other places in which large numbers of people are congregated together should not be allowed to blind the judgment of thoughtful minds to the extreme probability, if not absolute certainty, that under different circumstances many persons might have perished.

The object of the following paper is to indicate the principal points of safety and danger in such places, and to awaken general attention and interest to a subject of more or less personal concern to nearly all who live in civilized communities at some period or other of their lives.

In this country it is a good deal the custom to preach against what is called "panic legislation," and no doubt there is much to be said against it; but at the same time those who take a professional interest in matters involving expense in connection with the protection of life know well that the only chance of any legislation at all in this direction is when the public mind has been startled by a catastrophe, and that, consequently, it is their duty to prepare for this beforehand by offering such sound advice as their experience can dictate, and giving it as much publicity as possible, being confident, that although in the hour of safety it may subject them to severe criticism, possibly to the charge of creating the very panic which they desire to avert, nevertheless, when a serious disaster happens, it will be considered reasonable and moderate, and, judging from analogous cases, it may be assumed that after a great catastrophe restrictions and regulations of a much more rigorous kind than any here recommended would be imposed without the smallest hesitation.

The general subject must, in the first instance, be divided into several distinct and separate branches, including the external approaches, the surroundings, the building, the inlets, the internal structural arrangements, the internal police arrangements, and the means of egress, whether these latter do or do not serve also as part or the whole of the inlets.

It is unnecessary to go into any more minute details than those here given concerning points which are common to buildings of all kinds, such as, for instance, approaches, structure, &c. &c., especially as any further information which may be required on these branches of the subject can be obtained in my book on "Fire Surveys," published last year.

It may be that in the view of those considering the subject for the first time it may seem to be out of place for a fireman to point out matters connected with police duty, but such a view would be most erroneous, and could only be held by those who suppose police duty to be nothing more than the mere waiting and watching and patrolling which constitute the principal duties of a street constable. To those who think of it in the larger sense, as including all matters connected with the safety of life and property, it will probably appear that the packing of large numbers of persons within circumscribed limits, whether for religion, instruction, politics, amusement, or any other purpose, is a subject which should properly occupy the attention of those in authority as a part of police duty in its real and comprehensive sense, including the arrangement, management, and protection of the inhabitants of a city or state. In the particular matter now under consideration there ought to be a perfect co-operation of all those engaged in police duties proper as above described, whether they be sworn constables of police, firemen, managers, door-keepers, attendants, or others who have anything to do with the admission, arrangement, or departure of visitors.

The external street approaches should invariably be kept free and unobstructed, as they may at any moment be required for a rush of the audience, and the inlets, which also form the exits, should be not less numerous than the internal divisions of the auditorium, according to prices.

Each inlet should be easy of entrance at its outside point, well lighted, free from small projections or obstructions likely to cause injury, quite free from steps at any point where a crush is likely to take place, and gradually narrowing to the width of the narrowest internal passage through which the visitors have to reach their seats. In long straight passages, where the pressure of a crowd might be likely to accumulate so as to become dangerous, perfect safety can be obtained by placing at intervals strong barriers running from alternate sides, and so arranged that not more than fifty or some such limited number of persons could press on each other at a time. Obstructions of this kind carefully placed will be found not to delay the entrance of visitors, but on the contrary to facilitate it by removing all necessity for crushing, and so allowing them to walk quickly to their seats instead of being pushed and hustled as is too commonly the case.

As to the surroundings, it is to be observed that the safety of a building is very seriously affected by its position with regard to those near it. On this account a theatre or any building in which large numbers of persons assemble should under no circumstances be completely surrounded by other buildings. The practice of entering and leaving such a place by a passage or set of passages through other buildings, and not direct from the street, is one so obviously dangerous in the extreme, that it must be a subject of wonder how it can ever have been permitted in any country making even the pretence of superintending the care of its inhabitants.

If a theatre be surrounded on several sides by other buildings, it should have no windows or other openings in the direction of those buildings, and care should be taken that it should be so constructed that it would be impossible for it to be affected by anything happening in them. The practice, for instance, of allowing the roof of a building to lean against a theatre wall with openings in it above the point of contact is one wholly inconsistent with the safety of the visitors of the theatre. No rule can be laid down as to the distance to be allowed in towns, as so much depends on the nature and contents of the adjoining buildings, and the purposes for which they are used, but in any special case it requires but a very small exercise of intelligence to ascertain instantly by personal observation whether fire could be communicated or not.

In one country abroad thirteen feet is the minimum distance allowed between the walls of a theatre and those of the nearest buildings, and it is specially laid down that the intermediate space must be open.

Shops round theatres and forming part of the same block of buildings are always more or less objectionable, and even under the most favourable circumstances should on no account be permitted, unless the contents are safe from explosion, and the walls, ceilings and roofs able to resist any fire which could happen in them. This can be done without the smallest difficulty, and consequently there can be no excuse for omitting to do it.

To sum up this part of the subject, it may be said that a theatre would be most safe if standing alone, that every house in its immediate vicinity adds to its danger, and that its risk is greatest when it is entirely surrounded by houses.

This, of course, has no reference to houses built under the same roof, or in the immediate vicinity, for the special purpose of providing suitable and sufficient means of entrance and exit for the audience.

The external walls of a theatre should be strong, solid, well bonded both in themselves and to each other, and able to resist very considerable shocks. They should also be supported on the inside by all internal walls which touch them. Numerous instances have shown that there can be no greater mistake than to have a number of internal walls merely touching the external walls, and not bonded into them nor in any way contributing to the support of the structure.

In fact structural weakness in any part of a theatre which has to contain a large number of the audience, whether moving or stationary, is dangerous in the extreme, and should be guarded against by all possible means.

There are certain internal divisions in a theatre which are necessary for the transaction of business, as, for instance, the manager's rooms and offices, the dressing-rooms of the actors, the store-rooms, the stage, the auditorium, the passages and galleries of the auditorium, the corridors, refreshment-rooms, staircases, entrance-halls, &c. &c., and all these should be constructed of solid heat-proof materials, and should form an essential part of the building, instead of being, as sometimes happens, a mere collection of apparently temporary fittings just able to carry themselves and the persons ordinarily likely to pass over them, and of no service to the general structure, but, on the contrary, a source of danger to it on account of their great inflammability.

Some of the internal walls are necessarily placed at points at which it would be most desirable to separate the risks of the several parts; as, for instance, between the sides of the auditorium and the wings of the stage, and again, between the auditorium and the corridors, between the corridors and the stairs, and so forth, and the more solid and complete the walls are at these points the safer the building will be. In a theatre there are some parts which cannot be divided, as, for instance, the stage, and again the auditorium; and this it is which makes the danger of such places inseparable from their very existence; but there is no corresponding reason applicable to the whole structure; on the contrary, there are many why it is desirable in the interests of true economy, and especially for the safety of life, to divide the whole building into as many distinct and separate risks as possible, of course without at all interfering with the business to be carried on. For this purpose the first and most obvious point is that at which the curtain falls, as the opening at that spot is much reduced by the partial cross walls and the supporting wall under the front of the stage. In short, at this point the whole house should be divided into two distinct parts by means of a fire-wall commencing in the basement and going through the roof and to a height of from 4 to 6 feet outside. This wall should be perforated at the sides on each landing, and at the bottom under the stage near the orchestra, and fitted at the perforations with wrought-iron doors; and it should, of course, have the usual large opening to the stage, but with these exceptions it should be complete; and at the great opening an effectual protection could be obtained by means of a metal curtain which could be dropped at a moment's notice. The metal curtain should be supported and worked by steel or iron chains. Such curtains, it is true, have before now been tried and have not found favour with managers of theatres, but that does not at all affect the subject under consideration. They may have been badly made, badly fitted, or badly worked; but even so, it must be obvious that in the event of a fire happening they would have done *some* good.

At all events, in the present condition of mechanical skill and knowledge it is simply monstrous to say that the thing is impossible, and it is quite certain that there are thousands of the first engineers of this and other countries who would not hesitate to accept an order for such a curtain, and if not hampered by restrictions would guarantee that fire would not get through or by it under any circumstances whatever in less than an hour or so, which is much more time than would be required for saving first the audience, and afterwards the auditorium and other parts of the building. In all the other parts of a theatre separations can be effected by means of iron doors, and in places where iron doors cannot be fitted, wooden doors will be found better than none at all. The great object to be attained is the division of the whole building into the greatest possible number of distinct and separate risks, and the subdivision again of these into risks either wholly or partially separate, and the safety or danger of a theatre is precisely in proportion to the extent of this division and subdivision.

It is a grave reproach to our age to have to acknowledge, as we must do now, that the lives of many hundreds, in some cases several thousands of persons, may be at any moment placed in the utmost jeopardy through the carelessness or over-zeal of a scene-shifter or some subordinate assistant, who, however intelligent and well-intentioned, is always liable in the transaction of his business to cause the very kind of accident which may result in the destruction of the building.

If this sort of danger were necessary, that is to say, if it were inseparable from attendance at a theatre, people would still go, as they go into the hunting field, or on the sea, or, as sometimes happens, even into battle for amusement; but they would do so with their eyes open, and would be prepared to take the consequences, balancing the pleasure against the risk, and for such people it may perhaps be well to allow the present arrangement of theatres to remain unquestioned.

There are, however, others who prefer, when convenient and practicable, to separate their amusements from their dangers, and again the thoughtless thousands who have to take their amusements where and when they can, and who have neither time nor knowledge to estimate the dangers, and for the good of all such it would seem to be a duty either to remove the dangers altogether or to give ample warning of such as exist.

It may be difficult to remove the dangers altogether in the strictest sense of the words, making every portion of the inside of a theatre heat-proof, uninflammable, and incombustible; but to remove the dangers as far as they concern the audience absolutely, and the several parts of the building partially, is not only not impossible, but, moreover, not even difficult. It would of course involve an outlay of capital; that is acknowleged; but it would not interfere with any one of the objects for which theatres exist; on the contrary, it would facilitate many of them, and there is much probability that the extra outlay of capital would be repaid by a saving in current expenses.

A theatre should in the first place be divided into two principal parts, one before, the other behind the curtain. After this there should be the several great divisions of—in front—the auditorium, refreshment-rooms, and places for exit and entrance; and behind, the stage, the dressing-rooms, the workshops, and the store-rooms.

Then there are the subdivisions.

The auditorium proper cannot itself be subdivided, but the audience can be, and each portion ought to have a separate place for entrance and exit according to price, so that in case of an alarm or of anything happening which would require a sudden clearing of any part, there would be no obstruction at the immediate point of exit from the seats. It would be desirable that each portion of the audience should leave the building altogether by different passages, stairs, and doors, but this is not absolutely necessary for safety. If the several portions can leave their seats without obstruction, they may without much danger be allowed to join at some little distance, but in this case they should not be allowed to meet in a common passage either end on, or, if it can be avoided, even at right angles. It is much safer for the two streams to take the general direction of the common passage before they enter it. Then as to trifling differences of level, it will be found that gradients not exceeding one in ten are perfectly safe for a crowd, and that even the smallest steps are more or less unsafe. When there is a gradient, however, it is most desirable to avoid any pressure near it, as persons after entering a gradient downwards involuntarily attain an increased speed, and, if this be further accelerated by a pressure from behind, accidents may happen.

This danger, however, is very easily guarded against either by having the entrance to the gradient at a wide angle from the communicating passages, or by a simple arrangement of barriers at alternate sides reducing the number of persons in each compartment, so to speak, to about fifty or thereabouts, as this number cannot create a sufficient pressure to do injury.

In enclosed passages and staircases, hand-rails at a distance of about three inches from the walls on both sides are always an advantage. It is true that they occupy some space, and this is against them, but, on the other hand, they almost invariably prevent persons falling down and being trodden on. When a crush comes, the persons at the sides hold on to the rail, and those in the middle hold on to them; and it is most unusual

with such an arrangement for any one to be thrown down and trampled on, whereas in passages without a rail there is nothing to prevent persons falling, and, when they do fall, the consequences are most serious, not only to themselves through being trampled on, but to all in the vicinity, on account of the obstruction and the increased impatience or panic which is sure to follow it.

A hand-rail has also the advantage of giving those near it something to hold on to, thus enabling them in some measure to regulate the speed, and so diminish some of the worst consequences of a rush.

Each part of a theatre should be licensed and legibly marked for the number of persons it is to contain, in the same way as steamships, omnibuses, &c.; and it should be a misdemeanour here, as it is on the other side of the Atlantic, to occupy the aisles or passage-ways between the seats with camp-stools or chairs, to allow persons to stand in the passage-ways during the performance, or in any way to interfere with the free ingress or egress of the audience in the common aisles.

But to proceed with the subdivisions. The refreshment rooms should be separated from the auditorium proper by a sound, strong wall of masonry, with of course the necessary number of openings for the transaction of business, fitted with strong wrought-iron doors. The lobbies, corridors, and landings, should also be separated from the auditorium proper in the same way, and these should be of such a capacity that they could hold on an emergency the whole of the persons accommodated in the parts of the theatre opening on them. With such an arrangement as this, an audience would have an almost absolute certainty of safety in case of any accident on the stage, as there would be first the metal curtain, which would keep flames back for a considerable time, next the immediate exit into lobbies and passages, where they could shut the iron doors behind them, and finally the retreat into the open air, which under such circumstances could be made at leisure.

The spaces to be allowed for this purpose can be easily calculated.

A crowd can be packed in such a way that each person shall occupy only 1½ square feet, but such packing is very close, and where there is necessarily a movement, would be decidedly dangerous.

Even when packed less closely and allowed to occupy 1¾ square feet, there is no safety for women and children.

A number of grown persons placed together loosely, but touching, occupy upwards of 2 square feet each, or, to be precise, 21 square feet for every ten persons; but this is certainly below the allowance which should be made in the way of passages, corridors, and stairs for the kind of mixed crowd which constitutes the audience of a theatre.

As a simple rule it may be laid down that for every hundred persons in a theatre, the passages, stairs, halls, &c. with immediate access from the several parts of the auditorium, should comprise an area of not less than 250 square feet, and that the wider the passages and doorways are the more favourable they are for safety. Thus, while a space of 100 by 2½ feet would be sufficient, one of 50 by 5 would be preferable, and one of 25 by 10 infinitely better; but the great object is to have the space provided in any shape, and to have immediate access to it.

That the means of ingress and egress are not at present what they ought to be, is abundantly shown in many theatres by the practice of having a light piece to play the audience in and another to play them out; a practice which, as far as can be judged, seems to have arisen solely through the difficulty experienced in filling and clearing these places even when there is no panic.

Where this is not done, a large portion of the audience leave their seats before the conclusion of the performance, to avoid the inconvenience and delay of having to join the crowd in corridors and passages too small for the purpose.

In at least one country on the Continent the rule is that two exits are required to be provided for 300 persons, and three exits for 500, and the principle of making, not only the size, but also the number of exits, bear some recognized proportion to the audience, is decidedly a good one, and might with great advantage be adopted here.

As to the subdivisions behind the curtain, it is most desirable to have passages between the dressing-rooms and the stage, and these passages should be fitted with iron doors where they open on the stage. Such passages and all the dressing-rooms should be of strong masonry, well arched over and capable of standing the shock of anything likely to fall on them in case of fire; they should also have a safe outlet either to the open air or to some safe spot not in the risk of the stage. The stage itself cannot be subdivided, and must always be in one risk, but it can be effectually shut off from the dressing-rooms by passages, as above shown, and it should on no account be in direct communication with the workshops or the store-rooms, nor should these latter communicate directly with each other.

There are certain operations carried on within a theatre which form the especial and legitimate risk of such a building, but there are others which, though best carried on in the immediate neighbourhood, need not necessarily be done within the walls; both kinds will be considered separately, and it so happens that it is in some of the latter that the greatest danger lies.

The quick shifting of light scenery in the immediate vicinity of powerful gaslights, the intense heat caused by the lights in the upper parts over the flies and slides, the rapid manipulation of gas, oil, lime, and other lights for scenic effect, and the occasional use of explosives in the midst of a vast quantity of highly desiccated wood, a labyrinth of cordage, and a quantity of hanging drapery moving about with every draught and blast of wind; these and some others hardly sufficiently important for special notice, as for instance, trifling carpentering repairs, or glue-pot work on a small scale, constitute legitimate risks which may be sometimes capable of reduction, though they cannot be altogether abolished; and of them it can only be said, that they are generally well known among all engaged in a theatre, from the artists to the carpenters and other operatives, and that consequently very great caution is commonly used to prevent ignition of even the most trifling article of any kind, as they are well aware that the result would almost inevitably be the sudden blazing up of the whole.

The operations which need not necessarily be performed within the walls of a theatre are carpentering on a large scale, scenery-making, scene-painting, and decorating; and these, if carried on away from the building, are by no means specially dangerous. When, however, they are done within the walls, and subject to high temperature and desiccation as before explained, as well as to the chance of other materials suddenly blazing up near them, they increase the danger to a very serious extent. When again to these operations is added the storage of large quantities of timber, clothing, furniture, lumber, and the thousand articles known in theatres as "property," it will be seen that the danger is infinitely increased. The remedy here is, as before, a separation of the risks, first into two great divisions, the necessary and legitimate forming one, and those operations which can be carried on outside the walls the other. Then come the subdivisions, which unfortunately cannot affect the former, at least to any appreciable extent, but which can be freely and with great advantage applied to the latter. The workshops should be effectually separated from the scene-painting, the scene-painting from the lumber-rooms, the lumber-rooms from the clothing-making department, the latter from the property-rooms, and so on.

These rooms should be floored and ceiled with well burnt tiles laid in good cement or plaster; or, if preferred, the floors and ceilings might consist of cement or plaster alone; but it is essential that they should be solid, and not, as generally found, hollow, with air passages inside.

For convenience of business they might all open on a common passage if desired, but each should be surrounded by walls of solid masonry with iron doors, which on the first alarm might be instantly closed so as to isolate them.

In such rooms or in any part of a theatre, except when absolutely necessary, there should be no light inflammable materials forming part of the structure or fixtures. Everything should be of such a kind that it would under no circumstances blaze up suddenly when ignited, and should be as heat-proof as possible. Stairs, floors, and partitions should be composed of materials both heat-proof and uninflammable. All metals for this purpose are objectionable, unless the compartments are very small, in which case iron may be used with safety if embedded in plaster or cement, or covered in a strong casing of wood, which up to a certain point is perfectly heat-proof.

In the great divisional or fire-wall there should be on every level, from the basement to the roof, doorways as large as convenient fitted with double iron doors, which should generally be kept closed, but could be opened from either side when necessary, and there should be direct access to these doors from the several passages and corridors in front; and, in the event of the levels not corresponding, there should be light wrought-iron ladders fixed at the stage side, so as to insure immediate transit in either direction.

For the safety of the audience a theatre should be provided with at least two principal staircases, and these should be as far as possible apart, so that in the event of one becoming injured by fire or enveloped in smoke the other might be made available. It would be much safer to have two separate staircases for each part of the audience, according to price, leading from the lobby adjoining the seats to the hall of exit, so that half of each part of the audience might pass out by itself; but where there are two

main staircases, the stairs could be divided by longitudinal partitions, which would, to a certain extent, produce the same result by preventing undue crushing, and thus insuring rapid egress in case of necessity.

This should always be a special point for consideration where the safety of large numbers of persons has to be provided for. If one man in case of fire were to find himself alone in the top story of a theatre, he would immediately run downstairs and would almost certainly escape, and there appears at first sight no particular reason why a great many should not be able to do so as well as one; but those who have experience in such matters know well that the tendency of a crowd in such a case is to become excited, and that when excited they will push and hustle and struggle with each other, until, if it be possible to form a block, they will completely block up the way, and for a time render even their own egress impossible. It is therefore incumbent on those concerned to provide means of egress which shall be obvious to all, of sufficient size, not for an audience in their ordinary condition, but for one in a state of intense excitement, and which shall be either altogether free from obstructions, or shall have only the barriers or other obstructions necessary for general safety, and especially designed and fixed for the prevention of unnecessary crowding.

Stairs with bends at a right or even an acute angle are much safer than straight stairs. It is true that a uniform movement of persons passing down the stairs is to a certain extent desirable, particularly in a panic; and angles in the stairs interfere with this uniformity to a certain degree, as the persons on the outside of the bends have a greater distance to travel than those on the inside; but the absence of pressure is of greater importance than uniformity of movement, and consequently, where great crowds have to pass down stairs, angles are very useful. In some buildings too it may be possible to construct the stairs with angles in alternate directions, first right and then left; and thus, to a certain extent, to combine uniformity of movement with absence of pressure.

Care should be taken to prevent an undue accumulation of heat in any one spot, particularly over the principal light of the auditorium, and no wood or other inflammable material should be permitted in the immediate vicinity of this or any other place in which the temperature is necessarily high.

It may perhaps not be known to every one that in many theatres the carpenter's shop is situated in the roof over the main gas light, an arrangement wholly incompatible with the safety of an audience in case of fire.

Where there is glass round or over lights there should be a metal grating underneath to prevent broken fragments of glass falling and injuring persons or setting fire to the place.

All lights of every kind should be protected by hanging shades above to disperse the heat, and by cages or gratings round to prevent anything being blown on them, or coming in contact in any other way; and the footlights should, in addition to this, have a strong wire at a distance of about eighteen inches to prevent the actors coming into danger.

After the performance the lights of the auditorium should on no account be lowered until the whole of the audience has left. No excuse should be given for any one to light matches.

In every part of a theatre there should be a few oil or candle lamps kept lighted to prevent a panic in case of the gas being accidentally or otherwise extinguished.

When small repairs in painting or carpentering are unavoidable, they should invariably be done without artificial heat, and if possible without artificial light, and should be concluded at least an hour before the opening of the doors, so as to allow time for the discovery of any damage likely to arise from them. If artificial light be absolutely necessary, it should be supplied either by means of the fixed gas-pipe, which should be attended during the operation by the responsible gas-man, or by means of locked safety-lamps surrounded with metallic gauze, and in charge of a fireman or other responsible official who would know what to do in the event of an accident.

All stage lights should be guarded with metal wire at such a distance that any material coming in contact with it would be out of reach of the flame. It is better to have nothing at all over or around the lights than to have guards placed, as is too commonly the case, in such a way that they serve to hold falling materials within reach of the flame; as where there are no guards there is at least the possibility that the falling materials may extinguish the light.

Care should be taken to have all the chimneys carefully swept.

Chips, shavings, fragments of wood or other inflammable rubbish should not be allowed to accumulate within a theatre, but should be removed at least once a day, and, if only once, the time should be at least an hour and not more than an hour and a-half before the opening of the doors for the audience.

Every part of a theatre should be under the absolute control of a responsible official armed with the necessary authority for the work entrusted to him.

Thus, one man might have charge of the street approaches, another of the entrances and exits, corridors, stairs, and refreshment-rooms, others of the several sections of the seats, another of the dressing-rooms, others of the property-rooms, &c. &c., and the chief carpenter or machinist should be absolutely responsible for the safety of his department during the performance, the gas-man, scene-shifter, and all other persons engaged being under his orders for this purpose.

All these officials doubtless at present exercise some such functions as those here indicated, but it is more than doubtful whether their duties and powers are sufficiently defined for responsibility to be brought home to them in the event of a catastrophe. It is almost needless to observe that, unless they are intrusted with powers sufficient to insure the execution of their orders, their alleged responsibility, like the so-called fireman often found in theatres, is nothing but a sham. The distribution and consequent frittering away of responsibility is one of the curses of our time. It is like a foul disease infecting everything it reaches, and spreading wider and wider every hour; but there is perhaps no case in which it is so fatal in its results as where the lives of many depend on the rapid action of one.

Every theatre should have in constant readiness a supply of water under a pressure capable of forcing it to every part of the building, and in quantity sufficient to last until the arrival of external aid, and there should be a rising main and distributing pipes mounted with proper hydrants or fire-cocks in such a way that no part of the building should be at a greater distance than thirty feet from a hydrant.

A few years since an intelligent writer in this country proposed that a series of perforated pipes should be led all over the auditorium for use in case of need. The idea is an old one, but it has not, as far as I am aware, been adopted in more than a very few instances, and then only for extremely hazardous manufacturing operations. Indeed, there can be very little doubt that, with such an arrangement, a great power of destruction by water is placed in the hands of the person in charge of the command-cock, and that, as it makes but little difference to those who are only pecuniarily interested whether the loss is by fire or by water, there is generally very little encouragement to owners of property to adopt this plan. At all events, in the case referred to the idea was publicly and privately scouted by almost every one who treated of it, and yet the fact remains, that, however dangerous to property it might be to have a series of perforated pipes distributed all over the auditorium of a theatre, such an arrangement would make the safety of an audience in case of fire absolutely and completely certain.

There should also be a sufficient stock of portable water-pipes, or, as they are more commonly called, hose, with the necessary appliances to be able to provide two lines complete with everything from the principal entrance to the most distant parts of the building on each floor and on the roof, and the hose should be mounted with screws and other fittings of the pattern used by the public fire-brigade of the place.

There should be a few hand-pumps in pails and a large number of buckets distributed throughout the building in convenient places, and there should be on the stage, and in any pots where danger is to be specially apprehended, some buckets of water, hand-pumps, sponges, and wet blankets for immediate use.

A fireman, or in large theatres a staff of firemen, should always be present whenever any of the audience are in the house, and there should be small bells which could be rung from various parts of the building to call the firemen in case of any anxiety, without alarming the visitors.

By the term fireman here used is to be understood a man trained and instructed in the business of extinguishing fires, and not, as too commonly is found, a mere labourer, scene-shifter, or other subordinate assistant, clothed in a costume resembling a fireman's uniform.

The kings and queens upon the stage may be perfectly competent to reign in real life, and the generals and admirals to command; at least no one can assert that they are not so, until after they have been tried and failed; and by a parity of reasoning it might be inferred that the theatrically-got-up fireman may have the highest qualifications for doing what would be required of him in case of need; but it must remain a serious question with those responsible for the safety of life in theatres, if any authority responsible in this way exist in our country, whether it would not be safer to have no one at all than a man merely got up in the clothes to play the part.

This is a point on which I own that I can hardly offer an unprejudiced opinion, as I have spent so much of my life in

training men, and naturally believe that a sound course of theoretical and practical instruction, followed by experience gained in actual work, offers the best guarantee of favourable results in case of emergency; but in the present case I have endeavoured to lay aside my personal and professional bias for the moment, and to look on the matter from a wider point of view. It is, of course, advisable that one individual should be responsible for the condition and distribution of the fire-extinguishing appliances, and should be looked on as the leader or head, so that in the event of a fire breaking out there should be no conflict of authority even for a moment. Then, as a matter of course, it follows that the leader should have a distinguishing costume by which he could be recognized, and so let the question of uniform be conceded. But here the concessions must end, for taking a wider view still, it cannot be denied that it is contrary to all experience to find a man, however intelligent, suddenly developing at a critical moment so complete a power of command, that those who have never obeyed him or, perhaps, any one before, will be certain instantly to obey; and here it appears to me that the principal danger lies in the case of an unskilled man, as the slightest hesitation, awkwardness, or error on his part is certain at once to turn him into an object of contempt or ridicule, in which case his authority would instantly be at an end.

On the whole, therefore, and setting aside as far as I can all professional bias, I am compelled to incline to the opinion that it is only deceiving the artists and visitors, and encouraging in them and all concerned a false confidence, to put a man in fireman's uniform and entrust to him the duties of a fireman, unless he has the necessary qualifications for such a responsibility.

Then comes the difficulty of getting thoroughly competent men on reasonable terms, and in this I sympathize most sincerely with managers, as the very strong, active young men of a public fire-brigade, however trustworthy when working under discipline, and either in the immediate presence of their superiors or in constant expectation of a visit from them, are not always found capable of withstanding the numerous temptations which beset a theatre, and the older hands would not accept the position without very high wages.

But even here I think I see a way out of the difficulty. It would perhaps be hard on a manager to find himself called on to add to his staff some three or perhaps four men at wages certainly not less than about 35*s.* a week each; but, without presuming to speak very positively on the matter, I would venture to suggest that there seems to be no very apparent reason why he should not have about his premises in some capacity or other three or four times that number of officials or assistants taken from the public fire-brigade of the place, and consequently certain to know what to do on the outbreak of a fire.

The supplying of a fire watch from the public fire-brigade, as on the continent, being perhaps the best mode of all, might have been taken first, but I have placed the others before it, because such an arrangement has been tried here, and from want of numbers and other causes has not proved satisfactory; it is moreover to a great extent contrary to the habits of our country, and is certainly attended with very heavy expense, as the staff kept up here is barely sufficient for the work necessarily devolving on it, and every man withdrawn for even a temporary purpose has to be replaced by another, whose services must be paid for in full; so that, although a fireman may be only five or six hours on a special duty of this kind, it is necessary to charge for him a whole day's pay. Then there is the division of authority to be considered, and I certainly hold a very strong opinion that such a division would be most dangerous, and that nothing should be done by the fire-brigade or any public body to relieve the manager from the smallest portion of the responsibility, which ought to rest on him and him alone, of carrying out the precautions enjoined by law or public authority to insure not only the safety of every individual who visits his theatre, but also that reasonable amount of comfort which is a part of safety, and without which in my opinion real safety cannot exist.

I am quite sure that all the best managers would infinitely prefer themselves to undertake whatever the law requires to be done in their houses, rather than submit to interference from any public authority; and, if such a feeling exist on their part, I should say that it ought to be encouraged, and that, subject to inspection and proper supervision, everything should be left almost absolutely in their hands, except in one matter; and I do not think they ought to be allowed to dress up a man in fireman's clothes, and pass him off as a fireman, unless he has the necessary qualifications for the office.

As I have made suggestions about some of the attendants or assistants of a theatre being men who have previously served in a fire-brigade, I think it right to add that at present it would not be possible to provide a sufficient number of firemen for this purpose; but I have no doubt that, if the system were adopted, the men would be obtained eventually. I have carefully considered the subject from every point of view which presents itself to my mind, and I am clearly of opinion that in the first place the attendance of a sufficient number of competent firemen should be made one of the conditions on which a manager is permitted to open his doors. The mode in which the services of such men can be obtained is a matter of detail, which may very well be left to the managers themselves. The three ways which I have suggested have all their advantages and disadvantages.

The attendance of a staff of public firemen with their officers would insure the immediate adoption of the best possible measures in case of fire or panic, and would certainly give great confidence to the audience; it would, however, involve, first an amount of interference which few managers would stand, and secondly, an amount of expense which would seriously diminish the profits for which alone theatres are established.

The permanent hiring of properly trained men to act as private firemen, who would be the servants of the manager, would insure the men knowing the building and "the ways of the place" thoroughly, and taking a personal interest in the condition of all the fire-extinguishing appliances; but the services of such men are difficult to obtain, and so expensive, that even the most successful theatres could hardly afford to have a sufficient number.

Lastly, the appointment of skilled firemen to confidential and other posts would combine all the advantages of the other systems without, as far as I can judge, anything beyond a mere nominal expense, but there would no doubt be an unwillingness on the part of managers to find themselves called on to recruit their staff from one particular source; and for this I cannot deny that there would be some justification, though I think, considering the interests at stake, that the objection ought to be, if possible, overcome.

At all events, as I said before, I am of opinion that in addition to all other precautions, a sufficient attendance of real firemen should be made one of the conditions of opening the doors, and I have pointed out at least three ways in which such an attendance can be obtained.

In performances characterized by special danger, the hanging drapery and light movable parts of the scenery might be made dependent on a single cord, which could instantly be cut in case of need, so as to let the whole down in a heap on the stage, when it could be extinguished with water in a moment.

Clothes, drapery, hanging curtains, and all woodwork in a theatre should be frequently steeped or washed in alum water or some other substance, which would make them uninflammable, that is to say, which would prevent their blazing up in the event of their taking fire.

In October, 1867, the Théâtre de Belleville was burned through a wad from a pistol fired on the stage lodging unperceived among some decorations, where it smouldered for a time, and then burst into flame. The destruction of the building would not have resulted from this trifling accident if the fittings had been soaked in alum.

Much good might result from an inspection of every theatre by a qualified person previously to the opening of the doors, and again after the closing of the doors. In the former case he should see the metal curtain moved up and down, and should ascertain that it is in proper working order; in the latter case he should leave it down.

A watch might also with advantage be kept inside a theatre at night, and its efficiency would be increased by visits from the police or some one from the outside at irregular times; but this is simply a matter of private interest, as, after the audience has once escaped, it matters little to the general public whether the building be destroyed or not.

That the existing arrangements for the safety of theatres are not efficacious is shown by a high authority, M. Mauret de Pourville, formerly a sous-préfet, who took the trouble to collect statistics of losses in such buildings a few years since. This gentleman, writing in 1869 under the appropriate *nom de plume*, "Un Ancien Fonctionnaire," says that in the years 1867 and 1868 there were destroyed in Europe and America fifteen theatres, valued at between sixteen and seventeen millions of francs, or from £640,000 to £680,000; and some researches which I have had to make into the same subject have convinced me that his estimate is well within the mark. Indeed, one theatre alone—the Théâtre du Sultan at Constantinople—had cost over £240,000, or more than one-third of the whole.

It being then assumed that the existing arrangements are not satisfactory, it appears to be a duty devolving on some one to propose others.

The two objects to be attained are these: first to save the audience, secondly to save the property; and these objects will

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be best accomplished by subdividing both audience and building into as many separate risks as possible, and so arranging the general stowage of the contents as to prevent that sudden blazing up which has hitherto constituted the special danger of theatres.

All light, inflammable materials are dangerous; stores and other accessories add bulk, and so increase the danger; separate the two, and the risk is very considerably reduced.

All doors for the entrance and exit of visitors should be made to open both ways, and should be of such light material that in any great emergency they could be forced open, even if closed and bolted.

In conclusion, it may be asserted that, although a theatre badly built and imperfectly protected is not only dangerous in itself but a source of danger to all buildings in its vicinity, nevertheless there is no difficulty whatever, unless expense be ranked under this head, why a theatre should not be so constructed, divided, and otherwise laid out and arranged, that it might contain a smoking-room, and if necessary, even kitchens, with as perfect safety as the present refreshment saloons, and at the same time insure the absolute safety of the audience and the partial safety of the building and its contents in case of fire.

PEAT-COMPRESSING MACHINERY.

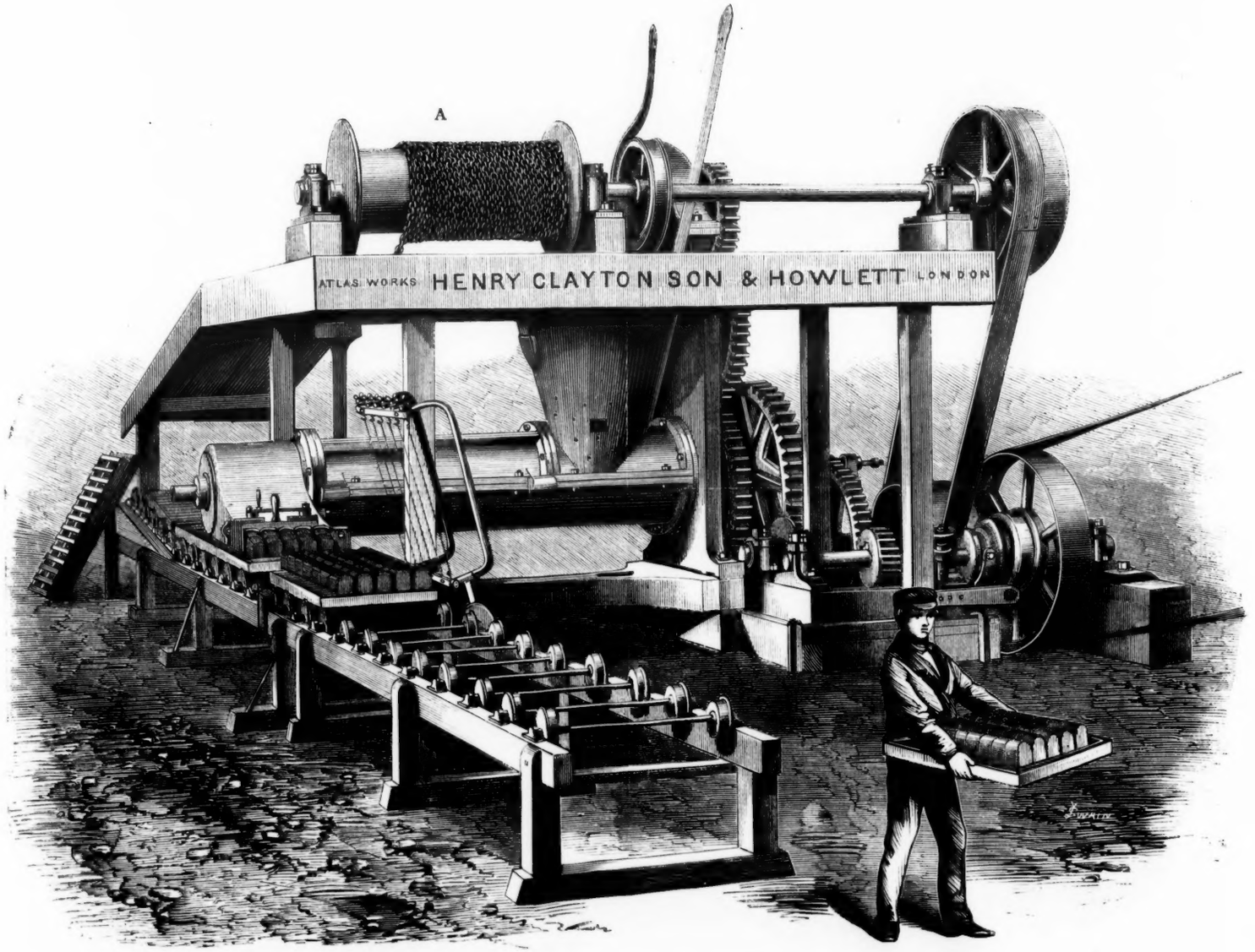
DEPENDENT as we venture to think this planet is upon *heat*, as the only means of producing and supporting human, animal, and even vegetable life, the best utilization of any of those substances which nature has placed at our disposal for the production of caloric is clearly a problem the solution of which is well worthy of the attention of all thinkers, and of those who try to labour and work for the benefit of their fellowmen. Looking back at the history of the world, so far as it is actually known, it is not unworthy of notice to remark how the earliest advances from mere physical life took place in those countries which were blessed with a climate which did not require the addition of much artificial heat, either as help to production or to the comforts and appliances of ordinary life; but as civilization has proceeded from the tropics towards the poles, its course can clearly be traced, and in no age is it more evident than in our own, by the increasing uses which mankind have made of the heat-producing materials which nature's great storehouse contains. The elder Stephenson's great saying that coal was light which had been hidden in the earth for thousands of years, is probably one of the most trite and apposite descriptions ever used; but there is other *light*, also, which has not been hidden, but which has been growing at our feet and lying before our eyes for almost an equal length of time, but which until lately has scarcely attracted the attention it intrinsically deserves. A first cousin, if not actually a nearer relation to coal, is the substance generally known as *peat* or *turf;* and its primitive uses as fuel in the countries where its chief deposits exist are coeval with the earliest records of history; yet it has been left to these later days to solve the problem of its best and most economical utilization. The essential difference between peat and the two other principal heat-producing substances, coal and wood, is, as regards the first, that peat contains hygroscopic as well as fixed water; and with reference to the second, that its fixed moisture is contained in a much more extended cellular system than that of any arboreous growth; and the real difficulty in properly and rapidly preparing peat for fuel is not to get rid of the hygroscopic, but of the fixed water. In time, of course, and with due exposure to a dry atmosphere, the cellular tissues contract, and the fixed water is evaporated, absorbed, and disappears; but, as we have said, this is a matter of time and exposure to heat, and when it comes to a question of quantity and supply, the uncertainty of the natural atmospheric action which would produce this result is one likely to prevent manufacturers and others requiring a regular and constant supply of fuel from trusting to the chances which would give it them.

We give an illustration of machinery which has lately been patented and introduced to the public by Messrs. Clayton, Son and Howlett, of the Atlas Works, London, for the purpose of so preparing turf, that it may, in a short space of time (and here lies the very essence of the process), be converted from a specifically light, cumbersome fuel, requiring large stowage room, possessed of but small caloric-producing power, into a compact, hard, clean, and highly combustible agent. To practical readers of the "Practical Magazine" it will not be necessary for us to point out, that in the machine we illustrate the motive power comes from the driving band to the right of the drawing, the initial of which power may of course be steam, water, or anything else; nor to point out the friction clutch between it and the overhead motion. We have also omitted, for the sake of clearness, the platform on which the attendant to the feeding and lifting apparatus stands; for the position of that will readily be understood from the drum and chain, as shown in our engraving; to work the gear handles, and generally attend to the filling of the peat into the masticating cylinder; and we have had less scruple about this, from the consideration that it might be quite possible to place the machine in such a position, especially in the event of water power being available, as to obviate any necessity for lifting machinery being attached to it. It may then be distinctly understood, that so far as the process of preparing the turf, the winding apparatus is entirely extraneous; but the peat being, by it or any other means, got to the mouth of the masticating cylinder, above which we have placed the letter A, is thrown into it, and is then treated by a system of knives or cutters acting between projecting snugs on its interior surface, thoroughly disintegrated and amalgamated, whilst a certain portion of the moisture escapes through the holes drilled in the lower part of the chamber. It is right here to mention that part of Messrs. Clayton's plan is to bring the peat from the bogs to the factories on what they denominate squeezing trucks, an arrangement which would certainly tend to get rid of the hygroscopic water, but at an expense that we do not think would be of good economy; for our opinion distinctly is, that it is not with this, but with the fixed or cell-contained moisture that the difficulty lies.

Forced down by the spiral action of the disintegrator, the peat at the bottom of the perpendicular chamber is received into the horizontal cylinder, and there, by the motion of a continuous screw, carried gradually along until it issues on to the portable trays by the five apertures shown in the illustration; it is here received on light wooden trays of the cheapest and simplest construction, cut by a wire and so divided into blocks of any desired size, and carried away to the drying shed, or frames, where, in the course of about a fortnight, it becomes sufficiently desiccated to be fit for fuel, and this without the application of any artificial heat. Here is a most essential feature in the process of Messrs. Clayton—one which, if it be realized, is the surest element of success; for hitherto the chief expenses of all prepared peat, or even wood fuel, are the costs of drying. In Western India, where persevering efforts were made—many of them under the personal supervision of the writer of this notice—to introduce the European high-blast furnace and puddling systems in the manufacture of iron; the great difficulty, although there were certainly other stumbling blocks, was that of getting rid of the moisture in the fuel. The sponge-like charcoal, although stored in well-roofed sheds, absorbed in the wet months nearly its own weight of moisture, whilst the billets used in the puddling and mill furnaces could only be dried (be it remembered that the saps are principally fixed moisture) by a very considerable expenditure of the very fuel which was being prepared.

But to return to the Clayton peat process. The yield from their machinery appears to be about one ton of perfectly dried fuel from six tons of raw peat, this proportion being of course variable in regard to the different qualities of the material used, its density, &c.; but we believe the foregoing is about the general average, and we are assured that the finished article—and a beautifully solid, clear-burning article it is—can be produced at about ten shillings per ton. As to its uses, we do not ourselves look towards it much as a house or steam-getting fuel, our own idea being that it will be found far more valuable for metallurgical purposes; and in view of the necessarily daily decreasing available timber in England for charcoal-making, we conceive that for the sinking down and hollow fires where coke-pig is prepared for tin plates and other best uses, it will be found most valuable, as in its desiccated form it is sufficiently hard to bear the impingement of the blast; indeed, we are of opinion that some specimens shown to us were quite equal to carrying any ordinary burden in a blast-furnace, and to bear the pressure at the tuyeres. It is also well known that in some parts of Bavaria, notably at Ransko, peat to the extent of 75 per cent. of the fuel used has been employed in the blast furnaces; and if non-condensed turf can be thus used, the really solid material produced by Messrs. Clayton and Co. would surely be far more effective.

We understand that many large proprietors of peat lands have already commenced operations with these machines, and with reference to the question of the carriage of the turf from the bog to the spot which may be selected for the manufacture, to employ the wire tramway system which was referred to in a recent number of this journal, and which, from its ready movableness, cheapness of construction, and general adaptability to primitive countries, appears to us just the fitting means of transit for such material as turf, the position of which as the deposit is cleared



PEAT-COMPRESSING MACHINERY.

off, necessitating a constant shifting of road, which with any known sort of ground line would be very expensive; in addition to this there would, we think, be but little difficulty in arranging to work both the wire tramway and the peat machine with the same engine, an economy of some importance. In conclusion we will venture to express our opinion that Messrs. Clayton, Son and Howlett's process, if not absolute perfection, is the best mode of utilizing our peat deposits, calculated to extend at depths varying from 3 feet to 27 feet, over some six millions of acres in the United Kingdom and Ireland, and representing a mass of caloric-producing material of immense value.

PURCHASE OF RAILWAYS BY THE STATE.[1]

THE discussion on this subject was resumed at the Rooms of the Society of Arts, on Thursday evening, June 26th, the Marquis of CLANRICARDE in the chair.

The Chairman, in commencing the proceedings, said he had had the greatest satisfaction in listening to the able speeches which had been made during the discussion, and, notwithstanding what had been said in opposition to Mr. Galt's paper, on the whole he was bound to say they had not the least shaken his conviction that the acquisition of the railways by the State would be a most excellent and desirable course to adopt. All who had had the advantage of hearing or reading Lord Derby's speech, would bear him out in saying that the objection to Mr. Galt's plan could not have been more forcibly stated than they were by that noble lord, and, naturally everything which fell from him fell with great weight. Notwithstanding, however, his powerful exposition of the arguments he submitted to the meeting, he had not succeeded in convincing him. The same with regard to Mr. Vignoles. Whatever fell from so experienced an engineer of course deserved attention, but he was sorry to hear him say that the plan of transferring the Irish railways to the State was brought forward only by persons who had injudiciously invested their money in the railways. Mr. Vignoles' age and experience were such that he must in former days have been acquainted with the real facts of the case, though it was evident he had forgotten them. He (the Chairman) recollected the circumstances attending the formation of the Irish railways, and so far from the railway proprietors coming to the State to ask for assistance, the proposal emanated from the Irish Government of the day, in 1835 and 1836, under that very able official and man of sense, Lieut. Drummond. He it was who brought forward a proposal for Government making the railways, and a plan was submitted to Parliament, with the approval of the late Lord Carlisle, and actually adopted by the House of Commons. It was therefore quite incorrect to say that stockholders in Irish railways suggested the transfer of their property to the State. It was with great reluctance that he differed from Lord Derby on this question, as he had the highest possible respect for his opinion, but it must be recollected that not only was the opposition raised to this measure generally raised by persons professionally connected with the railways, of whom he wished, however, to speak with the highest possible respect, but, at the same time, if they were to be guided by authority on this question, however high some of these individuals might stand, on the other hand there was the authority of Government in every other civilized country to the contrary. It might be right or wrong, but it was the fact that no other country had adopted the system which prevailed in the United Kingdom; even in our colonies and dependencies, wherever the railway system had been brought to any perfection, the Government had control of the matter, as one not to be thrown open to what was called—erroneously, in his opinion—competition. Even in this country was it the fact that there was free competition? Not only would such a thing be really impossible under the existing system, but the State interfered at every turn with every attempted amalgamation, and every plan for extending the railway system. This parliamentary system was very imperfect—for no one of competent authority examined into these competing schemes. When a committee was selected, care was taken that the gentlemen who constituted it should know nothing whatever of the circumstances of the country with which they were about to deal. As an instance coming under his own observation, he might mention that the last railway committee on which he was asked to sit had to deal with competing schemes in the north-east part of Yorkshire. Twenty-seven days had already been spent upon the matter by a committee of the House of Commons, who had selected one out of three competing schemes. When the bill came up to the House of Lords, he believed that the members of the committee agreed with him in rejoicing that they had such an easy task before them, supposing the whole matter to have been well discussed before the committee of the House of Commons. But after two days had been taken up in opening the case, they found it necessary to go very thoroughly into it; and after the three bills had been laid before them, they came unanimously to the resolution that the one selected by the committee of the House of Commons was the worst. In the end, no bill at all was passed that year, and ultimately the contending companies agreed among themselves, and a bill was passed different from any of the three which had been originally introduced. Now, was there any sense in such a system as that, necessitating, as it did, an enormous waste of money, when the whole matter might have been decided by a competent tribunal at a very moderate expense? Lord Derby and others had admitted that the financial difficulties could be easily removed, and he was somewhat astonished to hear that noble lord express himself to the effect that the possession of these railways would be a burden upon the State in a moment of difficulty. He should have thought that, at such a time, it would be of the greatest benefit that the railways should be controlled and sustained, if necessary, by the State. It never was proposed to give the railways to the public for nothing, but they would be most valuable property. Supposing even that, in a time of distress, not only the shares were depreciated in value, as they naturally would be, but that there was also a diminution of traffic, so that the returns might to some extent suffer, would it not be much fairer that such financial difficulties, arising as they generally did from some public action of the empire, such as going to war, or otherwise, should be borne by the whole country, than that the loss occasioned in such a way should fall upon individual shareholders who were in no way responsible for the causes of the depreciation? He believed it would be much less loss to the community as a whole, that the State should, with its powerful credit, bear any temporary difficulty of this sort, than that permanent loss, and perhaps ruin, should be entailed on individuals. He believed the experience of foreign countries had shown that railways did benefit the State, and that a vast sum of money had been wasted in this country upon their construction. Some two or three years ago, at a meeting of the Cobden Club, Mr. Gladstone stated that between one and two hundred millions had been lost in this way, but he should put it much higher. He believed this country had thrown away at least 250 millions by the system pursued, and if railways could be constructed which would afford the same accommodation, and more than that given by the present companies, for a sum of money smaller by the amount he had mentioned than what they had already cost, to say nothing of the question of ruin to individuals and families from disastrous speculations, it would certainly be a great advantage to the country. For all these reasons he thought that railways would be much better in the hands of Government; and although there might be difficulties, as there always were difficulties connected with any important change, he would ask why were the most eminent men selected to conduct the affairs of the State unless they were prepared to meet and overcome difficulties as they arose. He had no doubt these difficulties might be surmounted, and he hoped the present discussion would be useful, by calling the attention of those competent to judge to the subject.

Mr. CAULFIELD felt sure that the opponents of the transfer of the railways to the State could not find a more able advocate of their views than Earl Derby; but, nevertheless, he thought the public papers had already shown that his objections were not tenable; in fact, they fell to the ground by their own weight. In his opinion, it was simply a question of the time when it was desirable such a transfer should take place. He would not pretend to adduce all the arguments necessary to make it clear that the time had now arrived, but he might refer to a very exhaustive treatise on the subject by Mr. Galt, which he believed contained everything which could be said upon it. That treatise was brought down to the year 1855, and contained the essence of nearly all the Blue Books which had been issued on the subject, and a great deal more, which nothing but great research could produce, and the only question was whether events which had since taken place had in any way altered the conditions of the question. It appeared to him, however, that the reasons then alleged against private management of railways had since increased in force. The amount contributed to the railways yearly approached very nearly to the interest on the national debt, and for that sum it was quite certain that four times as much accommodation as was at present afforded could be obtained.

Mr. SAYWELL said he cordially agreed with the observations of Lord Derby at the previous meeting. This question was of great importance, but he was not one of those who were disposed to imagine that the transfer of the railways from private enterprise to the service of the State would result in an amount of infallibility not possessed under commercial direction. In talking

[1] Continued from previous Number—p. 64.

about the State it was necessary to ask what the term really meant. It meant no more than the particular political party which at any given time was able to command a majority in the House of Parliament, and he did not believe that such a body of men would be, as a matter of course, able to manage railways better than those who now conducted them. He opposed the project because they were met there in the rooms of a society instituted for the encouragement of arts, manufactures, and commerce, and he had always entertained a belief that arts, manufactures, and commerce were best promoted by private enterprise. He did not see, therefore, how he could consistently support a project which, to his mind, would have the effect of very much discouraging all private enterprise. It was evident that private enterprise could not enter into competition with the State; and though one gentleman had proposed that the railways should be put up to public auction and let by contract, that did not seem to be the view of the reader of the paper, who rather advocated that the State should take the complete management and control. If, however, the railways were let by contract, the objection felt by many to placing any additional power in the hands of Government would be removed. In his view, if the Government attended properly to their imperial duties they would have quite enough to do; and he quite agreed with the objection urged by Lord Derby, that the measure proposed would lead to the placing of an immense amount of political power in the hands of the Government, which was a thing which ought to be guarded against. They must not forget the long and bitter struggles which our forefathers had had to go through in securing the liberties which we now enjoyed. Those struggles were caused by the overwhelming power of Government, and any increase in that power in the present day would be sure to act prejudicially to the rights and liberties now enjoyed. It would not stop at the railways, as had been already said; the canals and steam boats would follow; and if the State once interfered with trading matters, who was to draw the line? It was not a question of raising the money; no doubt if the step were decided upon, the money could be obtained, but it was a serious question whether they were prepared to place such a large amount of power and patronage in the hands of any Government. He felt very jealous of any and every Government, believing that the Government of this country had quite as much power as was consistent with the preservation of free institutions. He was not one of those who objected to any power being placed in the hands of Government, for it was necessary that they should possess a certain amount of power, but it did not follow that they should become traders or interfere with commercial matters. Such things, he contended, were quite outside their proper functions. Postal and telegraphic communication stood on a different footing, because if at any time a state of war should arise, it was very desirable that such matters should be under the control of the State. With regard to economy, Mr. Frederick Hill had given a very striking instance of the advantage of the contract system over one of State management. It did not at all follow, however, that improvements were not to be looked for in railways, for having travelled a great deal, not only in England and Ireland, but also on the Continent, he was quite ready to admit that there was great need of large reforms, not only in railways managed by private companies, but also in those under State control. For instance, he should advocate the universal adoption of the block system, which, he believed, would secure entire immunity from accidents, at any rate from collisions, and a different construction of carriages, with communication from one end of the train to the other, would, he thought, be very desirable. But these matters could be done quite as well by private enterprise as by the State; and it must be remembered that the State itself was answerable for the greatest part of the waste of money which had been alluded to, as was abundantly shown in the case of the South-Eastern and London, Chatham, and Dover railways.

Mr. HYDE CLARKE said it was a great advantage in all such discussions to elicit individual opinions, but at the same time it was totally impossible that a great and important question should be decided by the views or opinions of any one person. The question before them was of the most momentous kind, affecting as it did the welfare of the whole community. It was a very common thing to say that the welfare of a country depended on its powers of production, but it must be also borne in mind that a very large proportion of the energies of the population were devoted to transport. This consideration entered largely into all questions of prices, whether of food or other commodities, and therefore in dealing with a question of this kind in such a country as Great Britain, which competed with all the nations of the world, it would not do to be led away by considerations whether they would prefer one party or another in power; but all the circumstances must be looked at in order to consider what would be best for the welfare of the country at large. At the previous meeting Mr. Bass had stated that he was a contributor to the extent of £140,000 per annum to the traffic of the country. Now this was very important, in comparison with other outlay in the employment of the labouring classes. The manufacture of Mr. Bass was one not confined to this country; it largely contributed to the export trade, and it was within the cognisance of many gentlemen present that English manufactures were now subjected to a keen competition on the part of those on the Continent, particularly on the point of cheapness of transit; in fact, the recent extension of the Austrian railways had enabled the brewers of Vienna, who, within a very recent period, had no share in the foreign trade, to compete with English brewers, not only in our colonies abroad, but also within our own empire. A matter of this kind, therefore, affecting the employment of a large number of the working classes, must be looked at from a higher stand-point than the question whether a majority constituting the Government was to be invested with any amount of prerogative or not. After all, Government was limited by public opinion, and public opinion in the interest of the country would govern this matter, whatever might be the individual views entertained. Of course, all were in favour of private enterprise—both theoretically and practically they must be so—but, at the same time, it must be borne in mind that those other powers of co-operation and aggregation which they possessed must not be limited. They had all been advocates of private enterprise with regard to railways; and for himself he must say that many years ago, when Mr. Galt brought this matter forward, he was one who strongly advocated private enterprise, and thought the period had not come when any other course could be adopted. All experience on this subject had shown that whatever errors had been committed in the past, with regard to laying out particular lines, they had given an example to the world with regard to railway construction. At the same time, it must be owned, on the other hand, they had, to a great extent, failed in administration. He would not enter into detail upon that point, because it was hardly right to take up the time of the meeting with the consideration of questions which had been so long and so fully discussed. They ought rather to endeavour, after bringing together a variety of opinions, to produce, if possible, a united sentiment and action on the part of the community, in order that the best possible result might be obtained. If, however, it was desired to ascertain the real value of railway management in this country, there was, perhaps, no fact more striking than that which came under their own notice a year ago with regard to the Midland Railway. It would be remembered that the metropolis was placarded with announcements to the effect that third-class passengers would be carried by every train on that line, and, of course, the same thing rapidly spread amongst the other railway companies. Now, twenty years ago Mr. Galt had proved statistically and practically that third-class passengers could be carried profitably by every train, and, in fact, the same thing had been proved even earlier, yet it took twenty-five years, at least, for the railway managers of England to arrive at a conviction upon that point, and they were now forced to confess that the operation was not only beneficial to the public, but profitable to the companies. But what led them to this? Simply the fact that they were coming before Parliament for further privileges with regard to Amalgamation Bills, and it was necessary to give a sop to the public. Now what was wanted was some system of managing the railways which would bring public opinion to bear upon them, and which should insure their administration in conformity with the requirements of the country. That was not the case at the present moment. It was only casually, and under circumstances of emergency of the kind to which he had referred, that any concessions, even for their own advantage, could be obtained from the managers of railway companies. It therefore became absolutely necessary that some other machinery should be provided—no one pretended it would be perfect—the machinery which was called that of Government, and which at all events was under the influence of public opinion. With regard to the Post Office, step by step they had been able to obtain from the Government department reforms suited to the exigences of the times, the benefits of which were enjoyed by all. He would not go into the question of the relative merits of a Government system; but what did that phrase mean? There were many kinds of Government; there was the old Government system of this country, and there was another system which raised up an empire in India—the Government of the East India Company. That was no more a Government of private enterprise than the Government of this country, and even in this country there were various kinds of Government management, some as bad as railway management itself, and some better. In dealing with the question practically, of course they would choose the best, and apply to a new state of affairs the experience of the past, so

that a practical and useful result might be obtained. To those who looked beyond mere political questions, and who looked to the influence on the commerce of the world of what was taking place during this era of competition, it must be apparent that they could no longer delay such a change as this whether they liked it or not. If, from their interests as railway shareholders, or directors, they were inclined to hesitate, the time, he believed, would come when, step by step, whole branches of manufacture would be injured, and the very men who were turned out of employment would force this matter forward as a parliamentary question. It was a great and important question to be considered on public grounds, and whatever had been the divergence of opinion expressed in the discussion, sufficient facts had been brought forward to show that it was fairly within compass that the transfer of the railway system to Government could be carried out. As to the financial part of the question, it was certainly surprising to find a man of standing and ability stating that the operation was an impossibility. It was known to be one of the simplest things possible. It had been treated as if it were a question of raising an enormous loan, like the French indemnity, whereas it was as simple as the common operation of a conversion, such as had just been carried out by the great financiers of this country for the United States Government on a large scale, and this, in the case of railways, the stock of which was held in the country itself, could be dealt with with still greater facility. He was greatly surprised to hear the statement that the transfer of railways would nearly double the national debt, and with all due respect, he could not understand what that statement meant. So far as he could see, the country was already in debt for this amount to the owners of the railways quite as much as to the owners of consols. Nay, perhaps more so, because of the system of monopoly which existed. Having, in former times, opposed Mr. Galt's proposals, he felt compelled to come forward now and say that whatever difficulties he had felt in the matter had been since removed by the course of events and the conduct of railway managers, and he was now thoroughly convinced that such a measure could not be much longer delayed. The only question, in his opinion, was whether any further delay at all should take place.

Mr. GEORGE JONES had been rather disappointed at the small amount of new ground opened by Mr. Galt in his paper. With regard to fares, for instance, the cheapest scale recommended by Mr. Galt was one farthing a mile, but this, he believed, was far too high. It was well known to engineers and machinists that a little grit, if allowed to accumulate, would prevent the smooth working of the grandest machine ever invented, and eventually, perhaps, stop it altogether. He contended that the practice of charging per mile was the grit in the machine which prevented the successful working of cheap passenger fares, and suggested that a system of charging per stage instead of per mile should be introduced, the stage being determined by the position of a town of a certain magnitude or of an important junction, so that there would be seven stages on the Great Western between London and Bristol, and eleven on the Great Northern between London and Leeds. Mr. Jones was proceeding to elaborate this scheme, when a gentleman rose to order, remarking that these were matters of detail, not in any way affecting the main question before the meeting.

Mr. J. A. FRANKLIN said he had had special experience in connection with Indian railways, and wished to offer a suggestion or two, but, as he was suffering from an affection which prevented his speaking, he had asked Mr. Kisch to present his views to the meeting.

Mr. B. KISCH commenced his remarks by observing that many speakers had assumed that the time must come, even if it had not already arrived, when the management of the railways must in some form or other be brought within State control; whilst, on the other hand, it had been argued that it would be highly undesirable that the State should in any way come into competition with private enterprise. The suggestion made by Mr. Franklin would, he thought, combine the advantages of the present system and of Government control, and it had this important feature, that it could be applied gradually. It was well known that railway stocks and shares might be divided broadly into two classes—ordinary shares and the various kinds of preferences and debentures. The latter class, although stated on good authority to amount to about sixty per cent. of the whole capital invested in railways, had no voice whatever in the management. Now, considering that the holders of this description of securities were, if possible, more interested than ordinary shareholders in the permanent prosperity of the lines with which they were connected, it seemed only just that they should have some control over the business, and Mr. Franklin suggested that these should be taken up by the Government, and that the influence thus given to it should be exercised in the interest of the public. The conversion could be easily effected, and a reduction of interest could be made by giving the present holders Government security.

Mr. HALE rose to order, suggesting that there was no necessity to occupy time by discussing these matters of detail.

Mr. FRANKLIN said this was one mode by which Government control could be exercised over the railways. The smallest amount at which they could be completely taken over by the State would be 700 or 1,000 millions sterling, whereas the plan he proposed could be tried at an expense of some 230 millions only. The private proprietors would also retain an interest to the extent of the ordinary stock, though virtually, as in India, where this system had answered very well, the whole control was in the hands of Government.

Mr. GALT said the question was not whether somebody could suggest some plan for the better management of railways, or for introducing more of the State element, but whether they should be transferred to the State.

Mr. BROOKE also thought they were rather going beyond the subject which he, as a London tradesman, had come to speak upon.

The Chairman remarked that the subject was a very large one, and it was somewhat difficult to say exactly what belonged to it, and what, strictly speaking, did not.

Mr. KISCH said he could not confine himself exactly to the question whether the railways should be purchased or not, unless the system on which they should be purchased had been agreed upon. What was proposed was that Government should become the purchasers of three-fifths of the capital, and that by virtue of their position they should then step in and assist in the management of companies, which they would naturally do in the interest of the public. At the same time the interest of ordinary shareholders would be watched over by boards of directors, similar to those at present existing. The difficulties of Government interference might be avoided by a permanent commission being appointed.

Mr. JOHN JONES said the commercial interests of the country seemed to be the chief motive power which had brought the meeting together, but those interests were not to be measured only by magnitude of figures. There were other principles involved. Supposing the country were to increase its exports and imports by 100 per cent., and if, at the same time, the wages of the people were not improved, or their condition in life at all advanced, would that be any benefit to them? There was nothing which pressed more hardly on the trade of this country than the Government—it was one of the greatest obstructives to improvement from the burden of taxation which was imposed, taking, as it did, out of every man's pocket that whereby he would fertilize his own neighbourhood, and make his business more prosperous, and his life more comfortable. And yet this Government, which was the preponderating burden on every man's life, did not seem to have attracted the attention of the speculative men who had brought forward this proposal. They spoke of the advantage of unity. On the same principle, no doubt, it would be an enormous benefit, and would tend to the diminution of the cost of Government, if France and England were to be amalgamated. That was Mr. Chadwick's great principle—the value of unity. See what could be saved in that way. The army and navy might be done away with, the courts of the two nations might be done away with, the separate systems of administration, all would be done away with, and what an enormous benefit would arise from the two nations combining together; but if such a thing were suggested, who would be the loudest to cry out "Home Rule"? No doubt his Lordship in the chair would be one; and this pleasing view of unity, with all its advantages and pecuniary benefits, would be abandoned in favour of some other principles, which were considered equally valuable to human life. Now, if the railway system were placed in the hands of Government, it would result in putting the working men connected with the railway, who were an enormous number, in a very disagreeable position. Supposing a porter or a guard insulted his inspector at a station, he would be dismissed, but there was no moral disgrace attaching to him, and he could go to another railway and get employment. If, however, the Postmaster-General dismissed any particular officer, he could not be taken on again at another place, but he was deprived of his livelihood altogether, possibly on account of such a trifling matter as offending some particular individual. This was a very serious matter when people talked about the interests of the working classes. Another consideration was this—Government had never initiated anything good since it first existed. One would have thought that all the best artillery would have come from the brains of men who were daily using it, and whose lives were passed in connection with it, but such was not the fact. Governments had always shown themselves incapable of any progress. They had never initiated new weapons for their own

service; and private persons outside had introduced the very things which they ought to see the men whom they employed provided with. The result would be, if the Government were to take possession of the great system of railways, which was still open to immense improvement from the genius of mechanicians, that a stop would be put to that progress. Men of talent had enormous difficulties to meet in pressing their ideas upon large bodies, such as railway companies; and this would be increased tenfold if the matter fell into the hands of Government. There was a great deal in the localization of power and convenience, and he believed if the Government were in possession, in full power, there would not be that aptitude now shown by localities in providing themselves with new conveniences, according to the particular wants of the neighbourhood. No doubt an immense waste of money had taken place through the action of the Legislature, in promoting litigation and contending schemes; but where perfect liberty existed separate from the competition of Government,—supposing a development of traffic between two towns,—it was open to any one to set the machine in motion for introducing the needful communication. A great deal was talked about the Post Office; but the great system never itself originated the idea of the penny postage. It was Mr. Rowland Hill, whose great talent and energy was far beyond that of the generality of Government officials, who had developed that system.

The Chairman, interposing, said that the merits of Sir Rowland Hill were world-wide, and it was quite needless to occupy time by descanting upon them.

Mr. JONES said the East India Company had been mentioned as an instance of good management of a country by Government, but he objected entirely to such a view. He contended that the East India Company was not a Government establishment, and was no illustration at all of the principle contended for. Another consideration was this, that if Government possessed itself of the railway system, the whole of the work would be given out in large contracts, and the result would be that the trade—which was now distributed among many different manufacturers, who were each able, possessing a moderate capital, to supply the wants of a particular district or railway—would be thrown into the hands of a few great establishments. Government must deal on a large scale, and it would be found that it would give all its machinery to one or two firms, all the iron rails to another, and many of the present manufacturers would have to go to the wall; in fact, the result would be that the vast majority of individuals would find it hopeless even to rise above the condition of servants.

Mr. BROOKE begged to say that he entirely endorsed the statement of the noble Chairman, with reference to the importance of this question, and the desirability of Government taking charge of the railways. He might speak on behalf of a large number of the tradesmen of London, who were in the habit of paying large sums to railway companies for carriage, and also of farmers and producers in the country, and he was quite sure they would all agree in supporting Mr. Galt's proposition. It was quite true, as had been said by the chairman, that many individuals and families had been ruined by railway speculation, and even those who were not directly affected had lost large sums, as he had himself, through the failure of those who had engaged in these enterprises, led into them by the brilliant prospects held out by the marvellous, able, and clever men whom Lord Derby had spoken of as the projectors of railways. These men had to consult the interest of their employers, and it was as true now as ever, that no man could serve two masters; therefore, they could not serve the public whilst they had to consider the interest of the railway companies. On this account it was that an increase constantly took place in their charges, and this led to the prices of all kinds of meat, poultry, fish, and vegetables in London being much higher than they need be. Government were now managing the telegraphs with very great advantage, for his experience showed that greater facilities were now given than by the private companies, and he had no doubt that as soon as they saw their way the charge would be reduced. The same with regard to the Post-Office Savings Bank and Life Assurance. He was quite satisfied that it would be a wise step for the State to take the control of the railways, and hoped it would be done as speedily as possible.

Captain TYLER then moved the adjournment of the discussion.

Mr. GREER, in seconding the motion, said he thought that most of the speakers had hardly perceived the exact subject before them, which was not whether the railways had been managed well or ill, as between themselves and the public, or as between themselves and their constituents, but whether the system of having railways managed for private interests was good for the State at large. His feeling was extremely strong that, viewed in the interest of the State, railways should be managed for the general good of the community, and not for the good of the shareholders. If the State would manage the railways, taking into account how much could be made of them, in the way of doing good to the country, he had no doubt that ten times the amount of work now done, in the shape of carrying passengers, and two or three times as much in the carrying of goods, might be accomplished with very little expense. Railway managers at present simply considered what was best for the proprietors. Now he might illustrate this by a thing which not unfrequently happened at a time when the Dutch had the monopoly of the Spice Islands. When there happened to be a very prosperous year, it was well known that, rather than that the price of the article should be lowered, they destroyed a large quantity of the spice, and that was unfortunately the principle on which railways were now managed. No one wished to impute wilful mismanagement to these gentlemen—it was simply that they had to consult private interests instead of the common good. If a uniform Government system were introduced, a great deal of mismanagement would be got rid of, and he must take exception to a great part of the speech of Mr. Jones, who found fault with Government, for he did not believe Government wanted to have anything to do with railways if they could avoid it, because it would give them a great deal of trouble. There was an impression amongst the public that anything in the hands of Government would necessarily be mismanaged or jobbed. But in the case of railways he believed such a thing was thoroughly impossible, for this reason—the railway system would bring the Government, or whoever arranged it, in communication with the people, and they could not perpetrate a job without somebody being damaged by it. Now-a-days everyone knew how to bring his grievance before the public, and even if newspapers were not read, or listened to, somebody in Parliament would get up and ask a question which the minister would be bound to consider and give a specific answer to. There was no class now not represented in the House of Commons, and therefore everyone who had a grievance could easily find somebody to take it up and speak for him. Why was it that the carriage of letters and the management of the telegraphs was so well conducted? Simply because the Government had greater means and facilities for conducting such matters, and, as a rule, the greater the system was, the more complete it would become, and the more the officials concerned in carrying it out would become adapted to the positions they had to occupy. All Government departments were extensive systems, similar to those which managed the railways. The East Indies had been referred to, and there, from the natural unwillingness of Government to interfere with private interests and to increase political power, they had not taken possession of that Empire until it was absolutely forced upon them. Still he believed it had been a great blessing to the natives of that country, and that a much better system of Government existed now than when it was under private management. He recollected when Mr. James Silk Buckingham, at a public meeting, stated that he had been turned out of the country because he presumed to establish a newspaper in India, and at the same period missionaries were sent home lest they should run the risk of endangering the goodwill of the people by interfering with their religious opinions. Now it was governed more like England, and it was much for the good both of the native population and of the public at home. He was quite convinced that it would be a good thing for Government to take the control of the railways, having for their primary object not the obtaining a revenue, but the fostering and encouraging of commerce, and the advantage of the community at large.

The discussion was then adjourned till Thursday, July 3rd, at eight o'clock.

Capt. TYLER, R. A., spoke as follows:—There is, I sincerely believe, no more important question to the future well-being of this country than the question which is now before us for discussion, and it is important for very obvious reasons. The prosperity of the country rests on its manufactures and commerce, and these again depend, and will hereafter still more depend, upon our railway system and upon the facilities of communication and cheapness of rates and fares which it may supply. In the same proportion that our means of intercourse and transport are improved and cheapened, just in that proportion, *cæteris paribus*, will the prosperity of the country increase; and, on the other hand, as they are fettered by obstructions or high prices, so will it be injured. In the struggle for supplying the markets of the world which will hereafter have to be encountered between our merchants and manufacturers and those of other nations, there is no element which is more important to watch over, or which is more under our control, than that of providing greater facilities and cheapness for communication and transport; and just as much as we neglect to take the best means of improving them, just so much shall we endanger and injure our position relatively to other countries, and just so much shall we detract from our usefulness, and tend to diminish the degree of our prosperity. None of us have, I believe, an idea of what this

country is capable of doing under a system of free railways. It is with these convictions, and looking at the subject from the highest point of view, that I approach this discussion; and I wish it to be distinctly understood that I do not appear here in anything but my private capacity, and that I do not appear as an advocate of any particular course to be pursued. An honourable member, indeed, during a recent debate in another place, stated that I advocated the State purchase of railways, and that I did so in the hope of obtaining promotion by that means for myself. I wish Mr. Julian Goldsmid were here to-night, because I should like to tell him that nothing is more unparliamentary than to impute motives, and to ask him to answer my arguments rather than to attack me personally. He entirely misconstrues all I have said or written on the subject, when he attributes advocacy to me, and my own feelings and convictions in regard to it are far above any miserable personal ambition. If I were to undertake the advocacy of the State control of railways I should go to work very differently. I should marshal such an array of facts, figures, and arguments as would, perhaps, astonish him; and I should not, I believe, find, if I were really to try, much difficulty in persuading those who are our masters—who possess the voting power in this country, and who are more interested in this question than any of us—of the objects to which their efforts should be turned, and the points to which their exertions should be directed. But, my lord, there is another reason why I am no mere advocate in this matter. It has been with me, during many years, a question, not whether the State control of railways was desirable, but whether it was avoidable; whether, sooner or later, it would not become inevitable. The arguments which lead to that conclusion I have often enough advanced, but have never heard answered; and as they are at the bottom of the whole question, and may be stated in a very few words, I may, perhaps, be forgiven for again repeating them. Competition between rival railway companies, in construction or working, or in both, has long been regarded as the proper and legitimate weapon in defence of, or the guardian of, the public interest in Great Britain. But the principle of competition, which is excellent as between butchers and bakers, which is generally good in trade and manufacture, which holds good by sea, where the way is open to all, cannot be considered to have succeeded hitherto, and threatens to die out as between the railway companies of this island. It is true that the controlling authorities of different companies have been, from time to time, foolish beyond conception in expending the money of their shareholders in fighting and competing with one another, and that the shareholders have not had the wisdom to direct, or the means to enforce, a policy more in accordance with their pecuniary interests. Vast sums of money have been wasted in Parliament, in law, in engineering, in construction, and in working, which might, properly directed, have been better employed in facilitating communication and improving accommodation. Competition may, therefore, be said to have failed as a principle; but, not only so, it is, further, in process of dying out. Combination has already proceeded with giant strides, and it is easy to foresee the ultimate result. The London and North-Western, the Lancashire and Yorkshire, and the Caledonian companies, working in intimate alliance with one another, already share between them one quarter of the railway capital, and one-fifth of the railway mileage, of Great Britain. Other large and counteracting combinations loom in the distance, and there is every reason to believe, as a matter of plain probability, that before many years are past the railway system of Great Britain will be in the hands of a few companies, who will again combine to form one huge joint-stock monopoly. It is true that the parliamentary committee of the present session has refused to legalize the amalgamations on a large scale which have been brought before it: but it does not necessarily follow that another committee will, in another session, adopt the same course; and even if Parliament were to refuse henceforth to sanction further combinations, it would by no means result that alliances would cease to be formed. Neither parliamentary nor any other authority can compel railway companies to persist in quarrelling and competing with one another to their mutual disadvantage, when once their directors and managers determine to adopt a more sensible and profitable course. It is only in the nature of things, and in the ordinary course of events, that combination should go on in the future as it has gone on in the past, and that there should be in the end ultimate and total, as there is now partial, monopoly of railway communications. This is the first step in the argument, viz. that competition has failed in the past in providing for the general public a maximum of accommodation at minimum rates and fares, and that, whether it has failed or whether it has succeeded, the time is coming when, for good or for ill, it will cease to exist altogether; and this leads to the further question, How is this joint-stock monopoly, which appears to be inevitable, to be controlled in the interest of the general public—in fact, whether any good practical system of State control can be devised, short of taking the railways, or a part of them, over altogether? This is the question which I have not seen answered and which it is so difficult to answer; and the more it is studied the more do its difficulties come to light. There are, of course, grave political and other questions to be weighed in considering the matter from the other point of view, as to what would be the result of State control, and these questions have been put forward by certain of the speakers, and notably by the noble earl who was good enough to address us on the first evening of the discussion. Some of them have been already met; and it would be impossible to explain more lucidly than was done in the leading article which the "Times" devoted to Lord Derby's speech, the fallacy involved in the expression that by the purchase of the railway system we should double our national debt. The strangest confusion between the acquisition of property and the accumulation of debt is evident in such an assertion. The French nation, unfortunately, doubled its debt by going to war with Germany, and it will suffer heavily and proportionately by its load of taxation in future years. But if, in place of engaging in that war, it had upon fair terms acquired complete control over its railway system, the result would have been so far different that it would have made a constantly increasing profit, instead of an overwhelming loss, by the transaction. All experience has shown that railway property is on the whole an improving property; and the liability which a guarantee of interest on fair terms on such a property involves is, therefore, very small indeed. As to the possibility of railways being superseded in future years, or in future generations, that is not worthy of practical consideration. There are only three modes of travelling:—1, along the earth; 2, through the water; 3, through the air. With those who contemplate the possibility of transporting an excursion train, laden with 1,000 passengers, or the contents of a heavy goods train—say 200 tons—even from London to Birmingham, or London to Edinburgh, under all circumstances of wind and weather, through the air, I for one hardly care to hold discussion. Inland water carriage has already been superseded for most descriptions of traffic by railways, and the only means of travelling which remains to us is in some way along the earth. It hardly seems likely that we shall discover better materials than iron and steel for rails, and it is still less likely that rails will go out of fashion for wheels to travel over. The prophecy that "men should run to and fro, and knowledge should be increased," appears to be now in sufficient course of fulfilment; and I think we may fairly conclude that railways are the latest improvement in locomotion that this earth is likely to see during the remaining term of its existence, and reject as impractical the proposition that railways are destined to be superseded by other means of locomotion, and that it is undesirable for that reason that a State should acquire control over them. The other difficulties which are, or are supposed to be, in the way of State control, I shall pass over lightly, not to take up too much of your time on this occasion. They involve questions of cost, of patronage, of the labour market and strikes, and of political pressure from different localities. As regards the cost, it has no doubt been much exaggerated. But railway purchase is perhaps an unfortunate expression, and railway control by the State a better one. The purchase need not be more than a guarantee of dividend and interest, and the fairer way to look at the question of cost is, perhaps, to compare the estimated amount of the guarantee with the estimated amount of the net earnings. The number of railway *employés* has also been exaggerated. It is difficult to ascertain it precisely, but the companies returned in 1869, for 9,796 miles and £25,743,502 of gross receipts, 116,270 *employés*. The proportionate mileage increase to the end of 1871 would give 182,499, and the proportionate increase in receipts would give, to the same date, 220,823. There cannot, probably, be more than 250,000 at the present time, and this is only a small proportion of the total number of *employés* now in the service of the State, including the army, navy, police, constabulary, civil service, &c. In the post-office alone the number directly employed is upwards of 40,000. The comparison between the *employés* of companies and those of the Government in a similar service is hardly worth making, though it has been receiving some warm attention. As regards railway work, the same officers and servants would do the same work for probably the same salary, and wear, no doubt, much the same uniform. The only difference being the initials on their cap, it is difficult to see why they should be more or less efficient. Their interest, in the same way, would lie in the way of pleasing their superiors, with a view to increased pay and promotion as early as circumstances would permit. Strikes are, as a fact, less difficult to deal with in the Government than in any other service, and especially when there are pensions to be obtained by remaining, and forfeited by sacrificing employment. Why political pressure

should be of more avail in obtaining railway than other advantages has never been explained. But, lastly, I come to the remedy which may reasonably be expected, and which might practically be applied. If State control be, as would appear only too plainly, sooner or later inevitable, what form should it assume, how far should it extend, in what way should it be introduced, and when should it commence? On these questions there are two main propositions before us:—1. Mr. Galt winds up his valuable paper by quoting a question by Mr. Gladstone, and an answer by Mr. Glyn, then chairman of the London and North-Western Railway, before the committee of 1844, to the effect that there was nothing to prevent the Government from making railways to compete with the railways of companies, and to the further effect that he (Mr. Glyn) would much rather see a competing line in the hands of the Government than in the hands of a company. And Mr. Galt advocates the construction by the State of new lines to compete with the old ones by way of reducing to a reasonable figure the demand for consequential profits, which have by some speakers and writers been so exorbitantly stated. 2. Mr. F. Hill, in his able speech, setting forth his own views and those of his distinguished brother, proposes that the State, having first acquired the control of the railway system, should proceed to let it out for working to contractors. Mr. Hill proposes that the contractors should engage to pay to the proprietors of the shares and securities of the railways the sum guaranteed by the State, and should, subject to that condition, compete with one another, those who would undertake to work on the lowest tariff, and generally on the most advantageous terms, obtaining the contract. These propositions deserve, both of them, serious consideration, but both involve considerable difficulties. It will probably be a long time before a serious proposition will be made to Parliament by any Government for the construction by the State of a new line from London to Liverpool, or between any other great centres of traffic, to compete with existing lines; and when such a proposition is made to Parliament there will be at least a possibility of its being rejected. The leasing of State lines to contractors on a very large scale would also involve very difficult questions, and do away to a great extent with the advantages of State control to be first, by the means of a guarantee of dividend and interest, acquired. Mr. Hill would require, it is true, "proper security for keeping up the plant in good order, providing against accidents, and so on." But these conditions, which seem to be so simple when thus stated, would be beset with innumerable difficulties and disadvantages in practice. The permanent way, the works, the engines, the carriages, waggons, and vehicles of various descriptions used on railways, are all objects which may be kept more or less in a state of efficiency. There may be thousands, nay, hundreds of thousands of pounds, of difference in their value, over a series of years, in a great railway system, according to whether they have during these years been kept up or run down. It would be a matter of enormous difficulty to obtain a fair valuation of them when handed over to the working contractors at the commencement of their lease, as compared with their valuation when taken over by the State at the termination of the lease. And not only so, but the advantages of State control would, in a great measure, be done away with. The reduction of rates and fares to a minimum consistently with undue risk and fair working profit to pay guaranteed interest must necessarily be an experimental process, extending over a long series of years. Every such experiment in any district would interfere with the profits of the contractors. Every question of additional accommodation, of extra trains, of alterations of speed, or of further facilities, would be an interference with their profits; and the difficulties of settlement in regard to such cases, involving constant references to arbitration, would be practically insurmountable, and would also be a great bar to the improvements which might otherwise be effected. And, further, the country would again be divided into districts, each of which would be in the hands of a leasing contractor or company. Each leasing contractor would be working for his own interest, and not for the common good. The rolling stock would be distributed in the hands of different contractors, and would not be available for universal employment. And, in fine, the ultimate result would be a worse state of things than if by combination all the railways came at last to be worked by three or four, or even one, large joint-stock company. These two propositions being, then, the former very unlikely of accomplishment, and the latter very undesirable to attempt, there is a third proposition which I would venture to bring under your notice as being also worthy of consideration. Even if the conclusion were at any time arrived at that it was desirable for the State to acquire control of the railway system, there seems no good reason why such a process should be carried out suddenly, but every reason why it should be done gradually and tentatively. Whatever risk might be incurred in taking over the whole railway system at once, very much less could accrue from an experiment upon one system; and it is easy to imagine many advantages which might be obtained if the State were to guarantee a rate of interest to be agreed upon to the proprietors of *one* railway company, and to acquire the control of its railway. Every desirable experiment might be tried as to additional facilities, as to reductions of rates and fares, and as to further accommodation. The State railway managed in the interests of the public would have all eyes upon it, and its managers would do their best, so as to compare as favourably as they could with the management of other railways by companies. Experience would be obtained, and evidence would be furnished, as to whether it would be desirable to extend the principle of State control at a later date. An opportunity would be afforded of giving instruction to a certain number of officers and soldiers, which is so much needed, and of the formation of a railway corps, which the War Department have not apparently seen their way as yet to accomplish, but of which we might feel the want most seriously in a future war. I would therefore venture to suggest to Mr. Galt the propriety of amending his proposition for the State to construct a new railway, and of substituting for it the project of acquiring the control of an old one. The former was perhaps more appropriate in 1844; the latter would appear to be, at the present time, the more prudent, the more feasible, and the wiser course for discussion and consideration. The object of such an experiment would be to give, under the circumstances of this country, the greatest possible impetus to railway employment and railway utility, with a view to the public interest, whilst the object of company management is, or ought naturally and properly to be, to obtain a maximum of net profit for shareholders.

Mr. DAVID KER stated that he was the author of the paper on this subject which appeared in the "Journal" of the society for April 24th, and that he had been for the last three years advocating the purchase of railways by the State. He had done this by correspondence, addressed to members of both houses of Parliament; and Lord Derby, in a note acknowledging his communication, and written before Mr. Galt's paper was read, concluded by saying:—"The difficulties which occur to me are not those which you have noted." The summing up by Lord Derby of the first day's discussion probably contained, therefore, the difficulties which pressed upon his lordship's mind, and these he would now shortly deal with, first remarking, however, that he did not consider the Earl of Derby as an opponent of State purchase, for probably if his objections were removed he would be in its favour. His lordship first said:—"Was it wise to make the State responsible for 600 or 800 millions of debt?" But it had been clearly proved that the transaction would be the conveyance, not of a debt, but of positive possessions in land, buildings, and tangible property of increasing value. Then, with regard to railways being superseded, and locomotive power being adapted to common roads, though it might seem a bold thing to say, he ventured to assert this was impossible. How could the enormous mineral and commercial traffic of the country be carried on by road steam engines, limited to a speed of six or eight miles an hour, leaving on one side the question of passengers? Collisions would be the rule instead of the exception, and the blocks would be innumerable. There must be a guiding rail to keep the up and down traffic separate, and why should not the present railroads be made use of? Every improvement, then, would tend to the advantage of the Government which possessed the rails. Aërial navigation he dismissed as too ridiculous for serious consideration, at any rate for goods traffic. No doubt improvements might be made in the means of locomotion, as, for instance, by the use of compressed air instead of steam, and this he apprehended would some day be adopted, to the great saving of fuel; but in such a case the State would be, not a loser, but a gainer, by the improvement. Mr. Bramwell had said that the inventive powers of the mechanic would be stopped, and a particular form of locomotive laid down as a pattern never to be deviated from. Surely this must be said in joke, when it was remembered that Government had adopted numerous inventions in small arms, and even advertised for more. The same with ironclads, big guns, and forts. As to the relations between the State and labour, he did not apprehend that any complications would arise; on the contrary, the Government would have a great advantage over private companies, for strikes took place in the latter case a hundred times to one in the former. In his former paper he had suggested a plan by which soldiers, after a period of short service, would be employed as porters and policemen on the railways; there would thus be a large reserve army, at no cost to the country; and under military law strikes could not take place. Then his lordship referred to what he conceived would be a difficulty arising from the exercise of local patronage, in the making of railway extensions; but it appeared to him that the

extensions yet remaining to be made were so insignificant, as compared with the fifteen thousand miles already existing, that the question was not worth considering. His lordship then said, in conclusion, that he had always assumed that if the State had to buy railways it must also take the canals, steamboats, &c.; but he saw no necessity of the kind. The argument used by those against amalgamations—and the State purchase was only amalgamation on a large scale—was, that the canals must be kept separate from the railways, in order to compete with them. In the same way, if the State took the railways they must compete with the steamboats and canals. When he first joined the Devon railways in 1846, third-class trains were run with every train, so that the Midland Company were not, by any means, the originators of the idea. Again, when he went to Ireland, in 1852, as manager of the Waterford and Central Ireland Railway, he carried passengers from Kilkenny to Thomastown, eleven miles, for threepence, rates which were, no doubt, too low for England; but he found trains were empty, and by lowering the fares he induced people to travel instead of spending their money in the public-house. What merchant would send out his waggons four or five times a day, with a load of five hundredweight each time, when they could very well carry a ton each journey? A locomotive, like a horse, should be made to do its full duty. He did not propose that fares should be lowered to such an extent as only to cover the working expenses, because he considered that would be unfair to the very large class of persons, including children and many married women, who never travelled at all. It would be much preferable that profits should be made which would go in reduction of taxation, and be a benefit to all. He had prepared a plan by which all the fares throughout the kingdom could be very easily arranged on a system of mileage. A person could go to a post-office and get a ticket for ten miles, which he could use at any time or in any direction. Carriages, parcels, dogs, and horses could be managed in the same way. He thought it would be more trouble for the Government to lease the lines than to work them themselves; the latter plan would be much safer for the public, and better for the *employés*. If anything went wrong it could be called attention to in Parliament, and would soon be set right. As to taking the railways gradually, he did not think it would answer at all, because of the disturbance it would occasion in the value of the shares whilst the process was going on. In conclusion, he begged to refer to his former communication to the "Journal," the statements in which he had never heard controverted.

Mr. W. J. GWYNN expressed his conviction that it was absolutely necessary, in the interest of the public, that the Government should take possession of the railways. Any danger of loss in times of depression could easily be guarded against by forming a reserve in times of prosperity; and he did not apprehend there would be any financial difficulties in the way of making the purchase.

Mr. GRAZEBROOKE said he had been for many years interested in this subject, and had paid great attention to it from a political point of view. The first of all benefits to a nation was cheap and easy communication. The prosperity of the present day was well known, and was often attributed to free trade, but was really attributable to the railroads, steamboats, and telegraphs, which contributed so much to the growth of commerce and increase of production. He was always anxious to agree with Lord Derby's conclusions, knowing the ability of that nobleman, but on the present question it seemed to him those conclusions were altogether erroneous. He agreed with Capt. Tyler that there were only three possible modes of communication; but he could not agree with him that railway communication had reached its ultimate point of excellence, or that the present system would never be superseded. Considering the growing intelligence and constantly increasing scientific knowledge of the present day, he saw no reason to doubt that the time would come when 100 miles an hour would be looked upon as slow travelling. By slightly increasing the width of gauge, and lowering the weights, this speed could be attained with safety, so that distance would be much more completely annihilated. Railroads, however, would still be required, and he must take exception to the assumption of Lord Derby that if they were superseded the loss ought to fall on individuals and not on the community in general. If they were superseded, it would be by something more advantageous to the public, and consequently the State should stand the loss arising from such supercession. Whatever means of travelling were adopted, in all probability the existing railroads would be available in part at least. It was a self-evident axiom that the Government ought to have the control of the arteries of communication, the railways, canals, and navigable rivers, because these means of communication ought only to be used for the common weal, and not for the advantage of directors or shareholders, however numerous. There was only one real solution of this question. Although it might be delayed, it must come at last. Day after day the process of amalgamation was going on between the various railways, and this could only result in the public being more and more at their mercy, in the rates and fares being raised, and in the public being mulcted for the benefit of the shareholders. That such a condition of things was being brought about it did not require much argument to prove, and that it was rapidly approaching was self-evident. Therefore the sooner Government took the matter in hand the better it would be for the nation. He quite agreed that it was not wise to give too much patronage to Government, but he did not very well see how it could be used for political purposes in the case in point, being so widely distributed. There would probably be a permanent railway board, which might be elected by the very men who now held the railway stock. No doubt there would be a responsible minister, who would be the creature of party, but he would only be the ornamental head of the department, the permanent board having the real management. No doubt there were advantages and disadvantages to be considered in such an important matter as this, as in all others, but there were very many evils under the present system of railway management. For instance, if a person took a return ticket, and was not able to return so soon as he anticipated, it was very unjust that the company should make him pay the full amount of the single fare without allowing for the extra half-fare he had paid for his return ticket. He believed the acme of railway prosperity would never be reached until railway fares were immensely reduced, so that a workman would have no difficulty in going forty or fifty miles for a job. But these facilities would never be given by the present managers of railways, who considered only the interests of the shareholders. Nor could it be expected, for, although he had not the slightest doubt that in the end such a reduction would be remunerative, there might very probably be a transition period of two or three years, during which the dividends might be lessened. Only a Government could be far-sighted enough to carry out such an important change, knowing that it could afford to wait until the return came in due time. The same principle applied to extensions; there were large districts in Scotland and other parts of the kingdom which might with great advantage be opened up by railways to civilization, but which could not be expected at first to yield profitable returns on the capital expended.

Mr. MUIR said the proposition before the meeting appeared to be that the State should not only control, but work the railways, and the majority of the speakers seemed in favour of it. He, however, took a different view, that the present system, which had arisen from private enterprise, should not be lightly interfered with. He deprecated handing over the public to the control of a body of Government officials, whenever they wanted to leave home. They had heard of the soldiers being porters, but if they were called upon for active service where would the railways be? At the present time the railways were, in theory, looked upon as highways, and any one might, theoretically, place a locomotive and carriages on any railway, and carry passengers. The difficulty, however, in carrying out any such idea was that, though railway companies were compelled to allow the use of their lines, they were not obliged to give other facilities, such as booking accommodation, water, and coke. The theoretical right, therefore, had not, practically, been of any use. His view was, that if Government interfered in the matter at all, they should only do so to the extent of acquiring the permanent ways, supplying booking-clerks, &c., and issuing tickets to any one who chose to place trains upon them. The trains, of course, must be run at proper times, and on payment of the tolls, which would be amply secured by the money paid for the tickets. The only objection he had ever heard made to this plan was that the trains would run into each other, but he thought this was just the way to prevent such a thing. If he were the conductor of a train leaving Euston Square at ten o'clock, and knew that one belonging to another proprietor left at five minutes after, he should take very good care to keep ahead, knowing he would be answerable in damages if he occasioned delay. It appeared to him that the responsibility of each train proprietor would lead to great punctuality and safety, especially when there were Government officials at each station and junction checking them. Something very much akin to this was tried for about twenty years in Pennsylvania, the trains being run over the lines by different proprietors at different times. By this means they would secure the advantages both of Government control and of private competition, and the latter was a point, in his view, of very great importance. For instance, the railways charged three shillings for the smallest parcel from Glasgow to London, but the Globe Parcel Express, a private carrying company, would perform the same service quite as expeditiously for one third of the sum. Thus private enterprise beat the railways in the conveyance of goods, and he did not see why the same principle should not be applied to passengers.

Mr. CAMPBELL JOHNSON thought the argument adduced by the Earl of Derby had been pretty well disposed of, but one or two points might bear to be touched upon once more. His lordship asked what would have happened if the Government had purchased all the canals and coaching businesses of the country? But the fact was, there was no reason whatever why the Government should go out of its way to interfere with commercial transactions of that sort. The railways were now the highways of the country, which the canals were not, and that was why the State ought to have the control of them. Then a fear was expressed as to the result, if railways were superseded by some new invention; but he apprehended means would be taken, by the establishment of a sinking fund, to provide against any contingency of that sort. How could he agree with the proposition that if there were any loss from such a course it ought to fall on individuals? It appeared to him that in a free country the Government and the people were the same—the welfare of the one was the welfare of the other—and saying that it was better for individuals to suffer than the State, seemed to him drawing an impossible distinction. This error unfortunately was constantly arising, and lay at the root of what was often said about the antagonism between labour and capital, or accumulated labour. He was, however, astonished to hear Lord Derby give his support to such a confusion of thought. Some persons said it would be better for Government to control than to possess the railways; but it must be remembered that, beyond a certain extent, the more Government interfered the more they diminished the responsibility of the joint-stock companies, and if any accident or catastrophe should happen, the latter would be very apt to disclaim the responsibility, and say that the action of Government had taken the control out of their hands. He thought the Government should take the whole matter into their hands at once, and not little by little, because of the disturbing influence it would have upon the money market, which might lead to something like national ruin. There was always a great reluctance on the part of the mother country to follow the example of the colonies, probably under the idea that it would be derogatory to her dignity; but the experience of India, the Cape of Good Hope, Australia, and other colonies, showed the advantage of the State acquiring the possession of railways. The case of Ceylon, however, was particularly instructive; a company had began to make the railway, but, fearing they were going to be ruined, gave it up; the Government then took it up and finished it, it being supposed that it would pay for itself in about fourteen years. The experience of a few years, however, had now shown that it would repay its cost in a much less period.

Mr. LANSDOWN remarked that no one could wish the State to take possession of the railways unless the public would gain something by it, and the question was, what would the gain be? The public wanted cheap fares and uniform treatment, neither of which they enjoyed at the present time. Mr. Galt had been twitted with not bringing forward an overwhelming case in favour of the purchase, but he apprehended the difficulty would be to find any one who was satisfied with the present system; and if cheap fares could not be secured in any other way, then, undoubtedly, it would be advantageous for the Government to purchase the railways. The present managers said it was impossible to concede cheaper fares, but it had been calculated that about thirty-five tons of dead weight were carried for every ton of paying weight, and if that proportion could be reduced to three to one, it was evident that the fares could be reduced to one-tenth their present amount, with the present locomotive power and rolling-stock. The railway companies would not do this, because it paid them better to carry one person for ten shillings than ten persons for one shilling. The public, on the other hand, would much prefer to travel ten times for one shilling, instead of once for ten shillings. On this ground he hoped that this discussion would lead to some practical result, and that a committee would be obtained to go into the question, and see whether something could not be done. It had been suggested that amalgamation would lead to a reduction of 25 per cent. in cost, but that would not result in a reduction of more than 5 per cent. in fares, and therefore that, by itself, would not answer the expectations of the public of what could really be obtained by uniformity of management. Railway managers received large salaries, and no doubt earned them, for they were a very able body of men, but their energies were not directed to the benefit of the public—not being the public's servants; their interest, in fact, was to get as much as possible out of the pockets of the public, and to give as little as possible in return. As regarded the mode of purchase, he saw no reason why it should not be gradual, in the same way as amalgamation had proceeded amongst the railway companies; and if the Railway Board were established, with powers of arbitration, he did not think there would be any great difficulty in arriving at a fair basis of exchange—not a uniform basis, of course, because it would not do to give the same for a company with depreciated stock and plant as for one in which it was all new, or had been kept up to the highest standard of efficiency. He did not apprehend that the gradual system of transfer would of necessity lead to stock-jobbing, or at any rate, such a thing might be prevented by refusing to recognize any factitious value in the stock of railway companies not representing a real improvement in the property.

Mr. BOURNE said he had been anxious to say a few words on the comparative merits and demerits of Government management, for on this the whole question must turn; but being unable to do so at that late hour, he would communicate his views to the "Journal" in writing.

Mr. CAMPIN thought that, as an abstract question, all must agree that the railways, which were now the main high roads of the country, ought, in some way or another, to be under the management of the State; still, there were many practical difficulties which would have to be seriously considered. He had enjoyed considerable opportunities of learning the views of the representative working men on this question, and generally speaking, he believed they were in favour of the nationalization of the railways, but then they were also in favour of the nationalization of the land, so that they were perfectly consistent. Some, however, regarded the nationalization of railways with a certain amount of distrust, fearing that they might be used for political purposes, by the coercion of *employés*—not so much the clerks and higher class of servants as the porters, plate-layers, and workmen, in whose case it was considered this kind of abuse was more likely to be exercised. It must be borne in mind that this scheme, if carried out, would put the railways in the hands of a Government such as at present existed, not of some Utopian perfect Government, which would spring up immediately such a change was decided upon; and Government action was not always the most pleasant to ordinary people. Those who had had anything to do with the Stamp-office, or any other department, would know that there was a great deal of routine and what was called red-tapeism connected with it, which was not very pleasant to those who came in contact with it. Two points, in particular, would have to be considered which had not yet been alluded to. One was the question of responsibility for accidents, the ordinary rule being that the Crown paid compensation to nobody; and the other was, how would the State deal with inventors? No railway system could be expected to work well unless encouragement were given to mechanical improvements; but every one knew the way in which Government treated inventors, and it had even been said the Government claimed, and intended in future, to exercise the right of using inventions without recompensing the inventors. If such a system were adopted, he need hardly say it would not tend to the improvement of railways under Government management.

Mr. GALT, in reply, said:—The paper I read on the purchase of the railways by the State, which has been the subject of discussion at four meetings of the society, was necessarily of a very discursive nature, and to do anything like justice to the subject I had to travel over a great deal of ground. That the question at issue might be fully understood, it was necessary to give a sketch of the several phases of our railway legislation, to notice in some detail the manifold grievances which the working of our railway system inflicted upon the public, and to discuss at a greater or less length the principal arguments in favour of and against the project of purchase. Thus, by the introduction of so many collateral subjects, the principal facts and arguments brought forward in support of State purchase have been, to a great extent, evaded in the course of discussion by those gentlemen who spoke in opposition to the measure. Might I be permitted, then, briefly, passing over all other matters, to restate my arguments and reply to the objections to them so far as they have been urged? First, I contend that, in the words of M. Rozier, the Belgian Prime Minister, in 1834—"Whoever holds the railways holds a monopoly, and, therefore, the principle of competition cannot apply." The British public, as we all know, determined when railways were introduced in England that competition should apply, and that there should be as free traffic on railways as on ordinary roads. Well, we know how the companies laughed at that remarkable project. Then followed competing lines. The companies were for a short time disconcerted, but they soon turned the tables on the British public, and made them pay pretty dearly by vexations, exorbitant and differential rates and charges for the useless expenses they had been put to. Under these unfavourable circumstances, another change took place in the British mind. It was thought desirable to pass a bill giving Government, with the assent of the Legislature, power to purchase the railways twenty-one years after date if the Legislature should so desire it, and the bill was accordingly passed. But in passing through Parliament it was so manipulated by the companies' representatives, that the only

intelligible part of the bill was a clause under which the companies claim, in the event of purchase, "consequential profits" to the amount of £400,000,000 beyond the present value of the railways. This was the Act of 1844, of which we had heard so much. After this Act was passed, it was thought advisable to conciliate the companies by allowing them to amalgamate, and this they had done at such a rate that if the Legislature had not taken fright and stopped them, they would by this time have divided Great Britain into four or five sections, and become supreme masters of the whole traffic of the country. The Legislature, however, thought there was one way left to establish something approaching to free trade in our railway system, and in the present session of Parliament an Act has been passed for compelling hostile companies to afford due facilities to other companies by giving them running powers over their lines, and a board has been constituted to carry this object into effect. I will read an extract from the evidence of Mr. Macpherson, the goods manager of the North British Company, given before the joint committee, from which an opinion might be formed of the task this board has before them, and the probability of their being able to accomplish it in opposition to the owning companies. The North British had running powers over the Caledonian line, and Mr. Macpherson thus describes the "facilities" afforded by that company in the exercise of their rights :—"They ran their trains in front of the North British and fixed the time for starting their own trains from the same places and the same hours, with the North British trains. They detained North British trains upon the ground of testing the carriage wheels, and on other unreasonable pretexts, in order to give precedence to their own competing trains. They refused to recognize North British tickets, and forced passengers to leave carriages going by the North British route into carriages going by their own route. When North British trains arrived at Perth, with passengers for the Dundee Railway, or for the line leading to Aberdeen and the north, the corresponding trains for Dundee and Aberdeen were then started for Perth without North British passengers, although the North British trains had reached or were within the precincts of the station. They refused the statutory accommodation for North British clerks and agents at the stations on the said railway. They refused to recognize the North British Company's right to issue season or contract tickets to passengers. They raised fictitious claims at their stations against North British passengers for excess fares. In winter they would not allow foot-pans to North British passengers, while they provided them for their own. They refused to insert the times of arrival and departure in their time-tables, as required by the Amalgamation Acts. Instead of delivering parcels from the North—addressed to places in England and elsewhere, or beyond the North British system—to the North British Company, at Perth, they carried them over the west coast route. They declined to carry on through carriages belonging to the North British Company from Perth northwards. These are all findings of the standing arbitrator with reference to passenger traffic. As regards the goods traffic, the arbitrator found that the Caledonian Company opened the North British Company's letters and invoices at stations, and made use of the information thus acquired to secure delivery by their own carting agents, and to canvass the consignees for their return traffic. They used their own forwarding notes for North British traffic coming into Caledonian stations, and so secured the forwarding of such traffic by their own and the London and North-Western routes. They took possession of North British goods traffic arriving at the stations on their railways, and delayed its delivery so as to give precedence to delivery of their own, in consequence of which traders using North British lines have been induced to use Caledonian instead. They usurped the powers and duties of North British agents and clerks at Caledonian stations, and so manipulated the invoices and forwarding notes as to prevent the traffic going by North British routes. They took the addresses from the waggons loaded with North British traffic and re-addressed the traffic so that it might go by routes most profitable to themselves. They insisted on settling traders' claims against the North British Company for damages to and delay in delivering traffic, and so created dissatisfaction among traders using the North British route. Those are also all findings of the standing arbitrator, and the result of all was that we were not able to compete for the conveyance of traffic under facilities of equal terms with them." This is a very fair specimen of the success that has attended the determination of the Legislature to apply the principles of free trade to railway traffic, and by giving running powers to rival companies, thereby promote competition. In those few cases where they do not unite, the owning company has such advantages that successful competition is hopeless. It could not be denied that the railway companies must necessarily have a monopoly of the inland traffic of the country, and all that is now attempted is to mitigate some of the worst abuses which result from the exercise of this monopoly. We have, in the second place, to consider by what means the State could interfere, so as to give the public the full benefit which cheap and rapid means of communication are calculated to afford. Now a monopoly is not necessarily an evil—so far from being an evil, it may be the means of effecting a great good, as, for instance, in the working of the postal system. We have, in regard to the post-office, a highly centralized system of management, extending over the whole of the kingdom and connecting the most distant cities, towns, villages, and districts with each other and with the metropolis. Would it be desirable then that the post-office, as a national institution, should be abolished, and that the duties now performed by that establishment should be left to the operations of free-trade and competition, as we find it developed in the working of our railway system? The post-office has the monopoly of the conveyance of our letters on one system, the railway companies that of the conveyance of our persons and property on a system totally opposite. Which is the better of the two? If the Government monopoly of conveying letters was abolished we would have no difficulty in tracing the course of the future post-office companies so soon as they were established. They would act, no doubt, as all other railway or trading companies act. Each company would charge whatever rate of postage paid best. We should, no doubt, have a hundred different companies battling through the kingdom for business; they would assert, like the railway companies, their "territorial rights;" they would repel invasion, they would not submit to be robbed of their "postal traffic," they would combine against each other and the public, and the postage would rise or fall from day to day, as they might be successful or otherwise in their several combinations or arrangements. The cities and towns would be well attended to at the charges that best paid, and the villages and districts which would not pay would be deprived of all postal communication. There would be no control, authority, or combined action throughout the country, till the companies would find it to their advantage to amalgamate their several interests, and finally by successive stages become one great company, having in their hands the whole postal traffic of the country, and charging what they thought proper for letters, newspapers, and parcels. Would anyone in this country wish to exchange that system for that of the present Government monopoly? If not, it only proves that there are cases in which a monopoly can be managed by a Government greatly to the benefit of the public; and there could be no better illustration of that principle than a comparison of the system which formerly existed with that now adopted since Sir Rowland Hill's plan of reform was carried out. The conveyance of letters at that time was conducted without any more regard to the general interests than was necessary to extract the greatest amount of money from the public. In this respect the unreformed post-office was not a whit behind the most obnoxious of its compeers. It laid on the most exorbitant rates; it guarded with the utmost jealousy any attempt to infringe on its patent-right to carry letters, and prosecuted with the utmost rigour trespassers on its domain. Although the cost of conveying a letter from one end of the kingdom to the other did not amount to half a farthing, the post-office charged half a crown, and so in proportion for lesser distances. All this was abolished when Sir Rowland Hill had the system changed, and the public benefit made the primary object, and commercial success only secondary. In the paper I read I referred to my evidence given before the committee of 1844, which proved the enormous reduction that could be made in railway fares with comparatively slight loss; and I furnished the committee with a tabular form, with an exact statement of the loss or gain to each company in consequence of the great reductions in fares. I will give a short extract from my evidence in which I referred to this table. On that occasion I said, "Now, if they would refer to these railways of which I gave the returns, viz. :—Leeds and Selby, Manchester and Bolton, Dundee and Newtyle, Glasgow and Greenock, Glasgow and Gankirk, Paisley and Renfrew, London and Greenwich, London and Blackheath, no matter to what extent the directors had reduced their fares—and in the cases I have given the reductions ranged from thirty to seventy per cent.—there was not a single company in all those cases had their dividends affected to a greater extent than ¾ per cent. per annum." I quoted to the committee, in confirmation of the probable gain by the general adoption of low fares, the report of the board of directors of the Glasgow and Greenock Railway, who had reduced their lowest class fare from 1*s.* 6*d.* to 6*d.*, the distance being 22½ miles. The directors, in their report for the half-year ending the 30th of June, 1842, say :—"It has been found that the increase of working expenses for an additional number of passengers is scarcely appreciable, and with the present number of trains fifty per cent. more passengers might be carried with a very trifling increase of outlay. So successful has the operation of the third-class fares been that it enables the directors to state to the shareholders that had

the modifications of the tax been obtained before the commencement of the present year, the result of the year's traffic would have been very different from that which they now lay before them. In the week ending the 21st of May, before the reduction took place, the number of passengers was 12,133; the next week they had increased to 17,332; the week after that to 19,621, and so on, increasing till the period in one week in the summer when there were 33,887 carried, and with a very trifling outlay fifty thousand might be carried." As the strength of a chain is tested by its weakest link, so the third-class fare must to a great extent govern first and second-class fares, reference of course being had to greater speed, as well as superior accommodation. I stated to the royal commission in 1865 that I considered the following scale would fully meet the wants and wishes of the public:—Express—First-class, 1½*d.*; second-class, 1*d.* Ordinary trains—First-class, 1¼*d.*; second-class, ¾*d.*; third-class, ½*d.* Goods or slow trains (once a day)—First-class, ¾*d.*; second-class, ½*d.*; third-class, ¼*d.* per mile. Excursion trains about half the present fares. These reductions are not to be compared with those made in the post-office, but the circumstances are quite different, nor could the proportionate increase of passengers be expected to be anything like the proportionate increase of letters. Previous to 1865, the Board of Trade, in their annual returns, gave the average fares charged by all the railway companies in the kingdom, and anyone who had never studied the subject would be surprised at the wide range of fares adopted by the several companies. According to the returns for 1863, the lowest fares charged in the kingdom was on the North and South-Western Company's. Their charge per mile for the several classes was $\frac{6}{10}d.$, $\frac{5}{10}d.$, and $\frac{3}{10}d.$, which for 100 miles would amount to 5*s.*, 4*s.* 2*d.*, and 2*s.* 6*d.* The highest in the kingdom was the Carmarthen and Cardigan Company. They charged per mile 3½*d.*, 2*d.*, and 1*d.*, or taking 100 miles, £1 9*s.* 2*d.*, 16*s.* 8*d.*, and 8*s.* 4*d.*,—the fares of one company having, on an average, more than quadrupled those of the other. In the work I published in 1865 I quoted from these returns the fares of forty of the principal companies in the kingdom, all intermediate between those I have noticed, drawing especial attention to the fact that the North and South-Western Company, even with their exceedingly low fares, was actually paying 6 per cent. to the shareholders, whilst the Carmarthen and Cardigan Company did not pay half that dividend, so little does the difference in fares affect the dividends. It would be almost impossible to over-estimate the value of the boon that would be conferred on the mercantile community, and, indeed, on the public generally, by the establishment of a low, and to some extent uniform, tariff for parcels and packages throughout the kingdom. The annual charge to the public for the conveyance of parcels is very small in amount compared with that paid for general merchandise, and does not probably amount to half a million. The exact sum, however, cannot be ascertained, as it is mixed up with receipts for general merchandise. Great, however, as the difference is between the two sums, I am almost inclined to believe that a low tariff for parcels, packages, hampers, &c. throughout the kingdom, would, with the general public, be even a more popular measure than a general reduction in the charges for merchandise. It would come more home to each household, and partake more of the nature of an abatement in what might be called direct taxation, than almost any other reduction of a similar nature that could be mentioned. The charges by many companies are exceedingly high, and in some cases almost prohibitory. If the railways were in the possession of the State, a uniform tariff for parcels throughout the kingdom would probably be one of the first measures adopted; say for a parcel not exceeding 3 lbs., 4*d.*; 7 lbs., 6*d.*; 10 lbs., 9*d.*; and 14 lbs., 1*s.*; and for every additional 7 lbs. or fraction of 7 lbs., 6*d.* As regards the conveyance of merchandise throughout the kingdom, and the manifold grievances under which the mercantile community suffer in consequence of exorbitant and differential charges, no other remedy has been suggested of any practical value than the transfer of the railways to the State. In the paper I read I noticed in some detail the benefits which would accrue to the nation from the possession of the railways, provided that they could be obtained at a fair price; and on that subject I have little to add to what I have already said. It was assumed throughout the discussion which took place a few months since at the Statistical Society that, as the Act of 1844 was a failure, the companies had the power of imposing what demands they thought proper, and it was then declared that £400,000,000 beyond the actual value of the property was the lowest that would be accepted by the companies. Now, as a matter of fact, the right of the State to make competing lines in opposition to the companies had not only never been disputed, but the chairman of the London and North-Western Company stated in his evidence before the committee of 1844, he should prefer opposition lines being made by Government, rather than by opposing companies, as in the latter case the old companies might be ruined, whilst the Government would never carry their opposition to such an extent. The assumption, therefore, on the part of some who profess to represent the companies, that in the event of the public coming to the determination to have low railway charges established throughout the country, that the companies have power to prevent that intention being carried into effect, is an utter delusion. Lord Derby said he "had not the slightest doubt that if the public really wanted the railways purchased by the State it could be done; the question of price would not present any insuperable obstacle." We need not, I think, discuss the terms of purchase further. Should the occasion arise, the Legislature and not the companies will be the supreme master of the situation, and will no doubt act equitably. When the Act of 1844 was passed, it was the intention of the Legislature that, in the event of purchase, the shareholders should have a bonus of 10 per cent. on the value. We have heard the opinion of Mr. Bass in this matter; he is one of the largest, if not the largest, holder of railway stock in the kingdom, and he says he will be only too happy to sell it at 10 per cent. beyond its market value if he can find any one willing to give it; but I am afraid he must wait some time before he meets with such an offer. Captain Tyler says, very truly, that the Legislature would be very unwilling to construct lines in opposition to those of the companies, and such, no doubt, is the fact; but I only refer to the dormant power possessed by the Legislature to exercise that right should it ever become necessary, in answer to the gentleman who spoke at the Statistical Society, and assumed that the companies could evade the Act of 1844, in defiance of the public and the Legislature, and refuse to part with the railways should the nation wish to possess them, except on such terms as they thought proper to dictate. It is satisfactory, however, to find that in the several meetings held here, no allusion has been made to such preposterous claims by any advocate of the power and rights of the companies. As to the *modus operandi* of purchasing the railways, there can be, I should think, but little difference of opinion. It must be by a gradual process from year to year, according to the state of the money market and the inclination of the shareholders to take Government stock at the market price, with 10 per cent. bonus in exchange for their shares; and the operation might therefore extend over some years, or it might be brought to a conclusion in a comparatively short space of time. It is not necessary to go into a minute calculation of the saving that would be effected by the substitution of the credit of the State for that of the companies. In the very able paper read by Mr. Martin before the Statistical Society, in which he went minutely into the financial position of every class of railway securities, he calculated that the annual surplus revenue would be nearly seven and a-half millions. According to the highest railway authorities, there would be a saving in working expenses by amalgamation of 20 per cent., that would amount to five millions more; but let us assume that both calculations are somewhat over-estimated, and that the amount saved would not exceed ten millions per annum, even then an enormous sum would remain towards meeting any supposed deficiency that might be caused by the adoption of low fares and charges. Now, so far as regards passenger fares, some gentlemen who have taken part in this discussion have objected strongly to what they consider the high fares I have proposed, and urged that no loss would be incurred by adopting a much lower tariff. They refer to the success of the penny postage, and contend that a proportionate reduction should be made on fares as was made in postage. The cases, however, are not by any means parallel—to send a letter from one end of the kingdom is one thing, and to go yourself is quite another. There are ten letters sent by post now for one that was sent formerly, but we never should expect such an increase in the number of passengers; perhaps they might be trebled. Our object at the present time should be to have such a tariff that all classes might be accommodated according to their wants and their pecuniary means, and that no person should be prevented from travelling who has the occasion or the wish to do so. Now, I consider that the tariff for the middle class, at the several fares of 1¼*d.*, ¾*d.* and ½*d.*, with return tickets at a fare and a-half, would fully meet their wants. As regards express trains, they are attended with great expense, and as the number of passengers is limited, there cannot be the same reduction in fares as by other trains; nevertheless, a charge of 1½*d.* and 1*d.* mile per would be a large reduction on the present fares. A train once a day for the poorer classes, especially those who have occasion to make long journeys, would confer on them a great boon. It has been suggested by Mr. Bidder that carriages might be attached to a goods train, and third-class passengers carried at a farthing a mile with good profit. I don't know any other matter that more deeply affects the interests of humble classes. Take the case of a working man who has occasion to remove with his wife and family—say, four children—from here to Liverpool, for which at present he would pay

£3 6*s.* 8*d.* But what a difference it would make to him if he had only to pay 16*s.* 8*d.*, although he should be three or four hours longer on his journey! It is to be hoped that those who possess great influence in the country, and use that influence to benefit the working classes, will direct their attention to this phase of the question. Besides the working classes there are many of the middle classes to whom a saving, in a long journey especially, is a matter of some consideration; and if they are satisfied to avail themselves of a slow and cheap rate of travelling, there is no reason why they should not be accommodated. With the above tariff, and excursion trains at half the present fares, I think the country would be fully satisfied. It is quite possible, with these reductions, that in the course of a few years there might be a greater revenue from passenger traffic than there is at present, but if not, there would be the reserve fund to supply the deficiency. As regards the goods traffic, I have gone so fully into that branch of the subject in the paper I read, in which I detailed the heavy grievances under which the mercantile community labour, that I cannot venture to trespass further on your time. I will only say in reference to that subject that all the rates and charges require the most careful revision, and large reductions when the circumstances of the case warrant it. It is admitted by all parties that, as such a system would affect the interests of the companies, it can never take place under the present system. But, with the large reserve fund that would be in the possession of Government, there would be a reasonable expectation that the charges on merchandise could be reduced, on an average, 25 per cent. Each class of cases would require special investigation by those best qualified to undertake such an onerous task. In some cases the reduction in charges would be very small, in others very large, but the main object to be attained should be a greater equalization of rates throughout the country, and a reduction of charges in those cases in which the cost of transport greatly augments the price to the consumer, or prevents, either entirely or partially, the transport of merchandise. In all the discussions which have taken place in reference to the purchase of railways by the State, the subject has been treated as though the State was a stock-jobbing company, of which the Government were the managers, and that if the saving to be effected by purchase and amalgamation would be insufficient to meet the deficiency caused by low fares and charges, the State would be an absolute loser by the transaction in the same way as any trading company. It is scarcely necessary to expose the utter fallacy of this assumption. How does the matter stand? It is calculated that the railway receipts for the present year will amount, in round numbers, to fifty-two millions, viz., twenty-three millions for passengers, and twenty-nine millions for goods. Now any reduction made in these charges is equivalent in every respect to a reduction in our taxation, whether direct or indirect. Travelling, and the conveyance of merchandise, are as much necessaries of life as tea, coffee, sugar, tobacco, spirits, wine, &c.; and in some respects a good deal more so, for some of these we might do without; but poor and rich alike must travel, and have their merchandise conveyed by railway, the cost of which must eventually fall upon the consumer. The payment of fares is as direct as the payment of income-tax, with this difference, that many people manage to evade the one, or pay an insufficient sum, whilst any one who attempts to evade the other soon finds himself in a police-court to answer for his conduct. Thus the enforcement of the passenger-tax is somewhat more stringent than the enforcement of the income-tax. As regards the amount of our payments to railway companies, it exceeds that of our payments in customs, excise, and income-tax combined, and in the course of a few years will exceed the whole of our present taxation. A reduction in railway charges equally affects all classes of the community, and is therefore in every respect analogous to a reduction in taxation. Now, if our fares are reduced to one half of their present amount, and the charges on merchandise reduced 25 per cent., the saving to the country would at present amount to nearly twenty millions per annum, which would be increased year by year, as the traffic of the country would increase. It, in this respect, is a simple debtor and creditor account. If the saving that would be effected by State-purchase, whatever that amount might be, would be insufficient to meet the loss, the difference would be a deduction from the nation's gain; if more than sufficient, the difference would be added to the nation's gain: and if it should so happen that there would be no loss whatever, the entire savings by purchase would be added to the savings by reduction in fares and charges. I am only speaking of the financial part of the question as regards the nation. I say nothing of the great benefit that low rates would confer on the country in respect to its commerce, nor how the wants and convenience of the public would be met by moderate and uniform fares. The last question I have to deal with is, perhaps, the most important of all:—To whose hands should the management of the railways be entrusted? Is it to Government, or must we look to some other quarter for that management which would give more confidence to the nation? Now, it is very remarkable that, in all the discussions which have taken place here and elsewhere, there has not been one word said by those who are opposed to the purchase of the railways by the State against the general principles we contend for. 1st. That by the amalgamation of the railways under one management a great saving would be effected in working expenses. 2nd. That as the credit of the State is so much better than that of private companies, the difference of that credit would enable the State to obtain the railways on very advantageous terms, if purchased at the market price and adding a liberal bonus to the shareholders. 3rd. From the experience we have had for forty years of the working of our railway system, that the difference in profit between high fares and low fares is comparatively so small that, under a proper system of management, a very large reduction in fares and charges could be effected without having recourse to taxation to make up a deficiency. Now all this has been tacitly admitted, but it is contended that these advantages would be more than counterbalanced by Government mismanagement. There are in addition many other reasons urged against the management of the railways by Government. "The really serious part of the question," said Lord Derby in his comprehensive speech, "was this—how would it be possible for the State to avoid exercising enormous local patronage, which would affect every district and town throughout the country? What he feared was the position of dependence into which every town would be brought towards the railway board or administrative body with which the decision would rest as to what new lines, stations, or extension of railway communication should be made. Every town in the country might ask at the same moment for extended railway communication, and it was quite clear the request of all could not be complied with at the same time. It would be necessary that a choice should be made, and that choice might be governed by political preferences. At any rate, whether it was so or not, you would never get it out of the heads of the people that it was so. This was a control, not over individuals but over the constituency as a whole, which no extension of the franchise and no manner of taking the votes would affect in the slightest degree. It would be very difficult to constitute the railway board in such a way that it would not be dependent on the minister of the day. An administration controlling a property of 600 or 700 millions, and employing several hundred thousand persons, would make itself felt in every corner of the country; if detached from the executive it would be an *imperium in imperio*, and if attached to it, it would not be easy to detach it from political party." These were the principal arguments brought forward by Lord Derby, from a political point of view, against entrusting the management of the railways to Government, and they require very serious consideration. In addition to the objection of a political nature, so clearly stated by Lord Derby, against placing the railways in the hands of Government, there are other objections, considered equally weighty, of a different nature, advanced from other quarters. It is contended that Government management is inefficient and wasteful, and that any board, however constituted, under Government control would be utterly incompetent to fulfil the various and complicated duties it would be called on to perform. Now, without discussing whether or not these objections are well-founded, it must, I think, be admitted that they are generally considered so, and for all practical purposes we must assume that the public opinion of the country is opposed to Government management. The governing body into whose hands the railways should be intrusted must possess the full confidence of the public, not only as regards its administrative capacity, but in the perfect confidence that the great power which it must necessarily possess cannot be made use of for political purposes, or in any other manner not in accordance with the strict and honest performance of its duties. This confidence the Government certainly does not possess, and if ever the purchase of the railways becomes an accomplished fact, we must look elsewhere for the governing body, independent of Government, with all the qualifications which the nation would require. What, then, would be the necessary qualifications for the members of such a board? They would require to be men of the highest social position and character, well known to the country, of mixed politics, the majority of whom should be thoroughly conversant with railway management, and all be members of either House of Parliament, an equal number to be nominated by each House, as in the case of joint committees. Would such a board possess the confidence of the nation and the Legislature, and be qualified to fulfil all the onerous and important duties attached to their office? If we can form an opinion of the future from the experience of the past, we should certainly come to the conclusion that no board or council appointed by the Government could carry with it the same weight, authority, and respect as a similar body appointed by both Houses of Parliament. Some time since an Act was

passed authorising the Board of Trade to report on the merits of the several railway bills presented to Parliament, but after a few years the Act was repealed, in consequence of the neglect with which their recommendations were treated. Compare that with the deference and respect paid to any recommendation coming from a joint committee. Take, for instance, the question of those great amalgamations which recently have so much engaged the attention of the country and Parliament. Government itself would not venture to give an opinion on the subject, but referred it to a joint committee, who soon disposed of it. Here we have a great decision given on the commercial policy of the country without a remonstrance or complaint from the companies whose bills were rejected, or that portion of the public whose interests their decision injuriously affected. For these reasons I consider no Board would possess such weight and authority as one nominated by the two Houses of Parliament, more especially as many members of both Houses have distinguished themselves as most able railway administrators.

Captain TYLER said it was not usual to pass a vote of thanks to the Chairman, but on that occasion he hoped the meeting would depart from the ordinary practice, and accord a vote of thanks to the noble lord who for three evenings had presided over the discussion.

Mr. BOTLEY seconded the motion, which was carried unanimously.

The Chairman said he was much obliged to Captain Tyler and the meeting. He had long felt a deep interest in this question, and entertained a very strong opinion upon it, long indeed before he had ever heard it mentioned in public. He had always held it to be a well-settled maxim that the Crown ought to have the control of the highways of the country; and when the railroads became those highways for all practical purposes, the Crown ought to take possession of them. He begged to propose a vote of thanks to Mr. Galt for bringing the matter forward with so much ability, for it was only by such discussions that public opinion on any question could be enlightened and consolidated. It was very satisfactory to find that no one had expressed himself entirely contented with the present system of railway management, whilst the majority were extremely discontented; and he hoped, therefore, the time was not very far distant when the question would be seriously brought before Parliament, with a view to settling the details of a scheme for putting railway communication on a proper footing.

The vote of thanks to Mr. Galt having been passed, the proceedings terminated.

The following statement has been sent by Mr. B. Kisch. It contains a summary of views held by that gentleman and Mr. J. A. Franklin on the subject:—

The evils of the present system, both present and prospective, are admitted on all hands, but the difficulties in the way of State purchase are also recognized to be enormous, and, even if such purchase were carried out, it is impossible to say what fresh difficulties might not present themselves. Lord Derby has pointed out many that would probably arise, and who shall say that even he has foreseen all? Captain Tyler, than whom no more practical authority exists, says,[1] "I would fain contrive, or see contrived, some method of averting or controlling the joint-stock monopoly which looms before us in the future. But I despair."

Those who have hitherto treated of this question appear to have seen no alternative other than a continuance of the present system, ultimately leading, as Captain Tyler shrewdly foresees, to a gigantic monopoly on the one hand, or an out-and-out purchase by the State on the other. No other or middle course appears to have been contemplated. Yet it would appear that a middle course, suggested by the system now in vogue on the Indian lines, presents a practicable solution of the problem, a solution which may be shown to possess, moreover, many incidental advantages over and above those which could result from a complete purchase by the State.

It appears from Captain Tyler's report that the proportions of loans, debentures, guaranteed and preference stock, and ordinary stock of railways in the United Kingdom in 1871 were as follows:—Loan and debenture (renewable), 15; debenture stock, 12; guaranteed and preference, 31; ordinary stock, 42; total, 100, the ordinary stock forming only 42 per cent. of the total.

In some companies the proportions are different, notably so in the Midland, which has lately been seeking amalgamation. Here the figures are as follows:—Renewable debentures, 10·19; debenture stocks, 13·03; preference stock, 41·69; ordinary stock, 35·09; total, 100·00.

Now, it is obvious that, as between the holders of the ordinary stock and the other sections of the proprietary, the former represent a fluctuating and temporary, the latter a stable and more permanent interest; for while it is the chief aim of the ordinary stock-holder that dividends should be increased to the highest possible degree, with a view to thereby raising, for the time, the market value of the stock, even though to the ultimate detriment of the property, the holders of other property in the concern have a greater interest in permanently maintaining the property. And yet it is the comparatively temporary interest in which the management of the line is in practice almost entirely vested. Debenture holders are not represented at any railway board, and the holders of guaranteed and preference stocks are frequently not represented. Now, mere justice should require that the proprietors of so considerable a stake in the company should have some substantial and organized control over the administration. But it would clearly be far more to the advantage of the companies that any such controlling voice should be given rather to a stable than to a fluctuating body; and of all bodies to hold such an interest, the most permanent would be the State. The plan suggested is, that so far as debenture and preference stock may be acquired by the State, the Government, by virtue of the proprietary rights so acquired, should, in the interest of the public, have a controlling voice in the management of the line, such as it always has had in the case of the Indian railways.

Many of the advantages of such a plan are obvious. The chief of all, however, probably is that it admits of being tried at once, and as an experiment, on any scale that may be desired, and, if found successful, of being gradually introduced. There would not necessarily be any compulsion on the debenture and preference proprietors of any particular line to part with their property to Government, nor, on the other hand, on Government to buy such interests indiscriminately. No comprehensive measure would be required such as might evoke serious opposition from any side.

In respect of various economies to be effected, the advantages that would follow are equally clear. Take, for instance, interest on loans, debenture stocks, &c. The credit and security of the State must always rank higher than those of the most powerful and best-managed company; and assuming, for illustration, that the ordinary capital were as much as fifty per cent. of the whole, a saving of one-half per cent. in debenture and other fixed interests would be a gain of one per cent. to the ordinary stock.[1] The facilities and advantages that the proposed plan would offer for the amalgamation of companies are not less remarkable. Amalgamation is at present resisted by Parliament in the public interest, and two applications with that object have been refused within the last few days, viz., from the London and North-Western and the Lancashire and Yorkshire Companies, which are to some extent competing lines, and from the Midland and the Glasgow and South-Western Companies, which are rather in the nature of one continuous line. Now, with a Government officer always at the board in the interest of the public, with a power to veto, such as is possessed by the Government representative on the Indian railway boards, there would no longer be reason to resist amalgamation on the ground of its tending towards monopoly; and the ordinary stockholders in the two amalgamating lines would reap the advantage of increased economy and improved administration.

The benefits arising to the public from the presence at the railway boards of an officer possessing power to suspend any action which may appear to be against the public interest, and to refer points of difference to a central, impartial, and independent body, such as the recently constituted Railway Commission, are so obvious that they need not be further dwelt on.

No part of the existing patronage, nomination of officials, &c., need be taken out of the hands of the companies, the power of the Government officer being restricted to a veto which would be used only in exceptional cases. This consideration also meets the most formidable objection raised by Lord Derby to State management, viz., that the State would become the largest employer of labour in the country, and would thereby become involved in all the questions between labour and capital which have lately come so prominently under discussion, and in which it has hitherto abstained from taking part.

Lastly. Should it be considered that precedent is required to justify the recommendation of a scheme such as here advocated, such precedents are not wanting. Besides the experience furnished by the Indian railways, gas and water companies supply other instances of similar bodies being gradually brought under administrative control. Moreover, boards of guardians, amalgamated into unions, now act under Government supervision; and we now see guardians, appointed by a minister of State, sit side by side with those elected by the ratepayers, a precedent

[1] "Journal of the Statistical Society," June, 1873, p. 221.

[1] In the case of the Midland Company, referred to in a former paragraph, the capital upon which economies may be effected is 65 per cent. of the whole.

going far beyond what is here proposed, inasmuch as the guardians administer what they believe to be entirely their own funds. In the face of this general tendency of the age towards bringing all departments of public service under State supervision, it is difficult to see what valid objection can be urged to applying the same policy to railway management, when it is shown that the difficulties with which the matter at first appears surrounded are capable of being cautiously and progressively overcome. The safety of this plan, due to its capability of being introduced tentatively, is apparent by contrast with the general result of rushing from one extreme to the opposite. The centralization which ruined France under the Empire, has led to general measures of decentralization.

Postal Telegraph Progress as Compared with Trading Companies' Progress.

Extract from Mr. Chadwick's Letter of Questions on the Trading Telegraph Companies' Allegations.	Answer.
"For its own part, and for the other companies, the Electric and International Company deny that 'many important districts are without any such means of communication.' They challenge the Government to prove that issue!" What was the total number of stations taken over? What the total number now?	The total number of stations worked by the old companies immediately prior to the transfer in January, 1870, was 2,932. The total number of stations opened since that date is 2,858, making a total of 5,790 now open.
"The Government Bill declares 'that the means of communication by electric telegraph are insufficient.' In what way are they insufficient? There is no country in the world which can compare with Great Britain in this respect. There is no country in the world which can compare with Great Britain in respect of the speed with which telegraph messages are conveyed."	The means were insufficient, inasmuch as they did not carry telegraphic communication into the 2,558 places referred to above. It may also be remarked that whereas the average number of offices to population in Europe is 1 to 16,118, the average number in the United Kingdom is 1 to 5,495. I am not aware of any country in the world in which telegrams are conveyed at a greater speed than in this country, owing principally to the use of the Wheatstone instrument on the more important circuits. Messages are daily conveyed between London and the principal towns at the average speed of 80 messages an hour on one wire.
What was the total number of messages then (or in the first month, say, of the change), and what is the total number now?	The total number of messages forwarded during the first three months after the transfer was 2,326,639. The total number of messages forwarded during the corresponding period in this year was 3,843,511, being an increase of 1,516,872.
To what extent does the condition of Great Britain now compare with its condition then as respects sufficiency and speed?	The other answers generally reply to this question.
What is the comparative speed? Is it not in the reduction of porterage by the multiplication of stations?	By bringing the telegraphs nearer to the population, the time occupied in the transmission of a message is not only greatly reduced, but a large saving is also effected in the charge for porterage; and in the majority of cases no charge whatever is made, as messages are delivered free within one mile of the terminal station.
Messrs. Chadwick and Scudamore based their whole argument before the Society of Arts upon the facilities which the Post Office would afford to the working of telegraphs in small towns, villages, and country districts. Their notion was that the village post-master or post-mistress would act as telegraphists. "In the first place, the persons employed at country post offices are, as a rule, quite unfit to be employed as telegraphists." How is it now, "as a rule;" what proportions are so employed?	About 2,800 post-masters and post-mistresses are employed on telegraph work, and judging from the fact that only one complaint is received concerning every 1,379 forwarded telegrams, it would appear that the work is done in a satisfactory manner.
"It is worthy of consideration that ours is the only country in which the telegraphs are not a monopoly in the hands of the Government, and it is also worthy of observation that, under a system of free competition, we have made more progress and arrived at a higher standard of excellence in telegraphy than in any country in the world." What improvements have been adopted, or are in process of adoption, since the system has been in the hands of the Government, beyond the system in the hands of the companies?	(*a*) We have brought the proportion of telegraph offices to the population from 1 to 10,852, to 1 to 5,495. (*b*) We have given a free delivery of not less than one mile, whereas formerly it was only half a mile. (*c*) We have reduced the rate to 1*s.* for 20 words for the whole of the United Kingdom, whereas formerly the rates were in some cases as high as 4*s.* for 20 words. (*d*) As stated in answer No. 1, we have carried the telegraph, in less than three years and a-half, to 2,858 places which were formerly unprovided with it. (*e*) Where two or three competing offices were situated within a few yards of each other, sometimes next door, in the busiest portions of a city, we have separated them and distributed them to other parts of the town. (*f*) For press messages we have reduced the rate to 1*s.* for 75 or 100 words, as the case may be, according to whether the message be sent by night or by day. To show how much the press have availed themselves of this facility, we may mention that as many as 18,000 words have been supplied by telegraph in one night to a single newspaper. (*g*) We have also given to the public, on advantageous terms, the exclusive use of private wires, and the revenue from this source alone is upwards of £38,000 per annum. While the Post Office has effected considerable improvements in nearly every description of apparatus in use by the old telegraph companies, it has largely extended the use of the more modern and rapid forms of apparatus, and is even now engaged in testing the practicability of still further improvements. The Wheatstone automatic system, which had been little more than introduced experimentally by the Electric Telegraph Company at the date of the transfer, has become a primary system under the Post Office, and its use is being almost daily extended. At the central station, forty sets of this description of apparatus have taken the place of the four sets in use by the company, while a large number of provincial offices have had its use extended to them. A new application of the system has also been introduced in the transmission of news for the press throughout the country; and the preparation or "punching" process, as it is technically called, has been so far improved that three slips can be produced without any increase of the labour formerly necessary to produce one. This enables us to transmit items of news for publication over three wires simultaneously, instead of having to "punch" it three different times. The "Bell" instrument of the late Magnetic Telegraph Company has been practically superseded by the "Morse Sounder," a much simpler and more generally applicable form of apparatus, besides being much cheaper. In a large number of cases, too, the comparatively slow and uncertain single needle instrument has been replaced either by the Sounder or the Morse printer; while the use of the type-printing instrument of Professor Hughes has been very considerably extended. The most recent improvement, however, is the introduction of the "duplex" system, by which two messages can be sent over the same wire in opposite directions at the same time. Some ten or twelve years ago this system was tried in this country, but, owing to the then imperfect condition of the lines, the experiment was attended with little or no success. Now, however, its success has been placed beyond doubt, and there are at the present moment no fewer than eleven cases at the central station alone in which the productive capacity of a wire has been doubled by this means. To these improvements in apparatus must be added the improvements in the construction and insulation of the lines, and the provision, to a large extent, of alternative routes where only one wire hitherto existed. The Post Office has also established a special staff, and a travelling or "field" telegraph office, by means of which telegraphic communication can be established at the most remote points at the shortest notice. Carrying its own cable and "paying out" apparatus, it can be attached to the main lines of telegraph at almost any point.
"In matters of telegraphy experienced and practical officers are required, and the pressure usually put upon Government members to obtain places for their supporters, without any regard to their capabilities, would scarcely be likely to operate advantageously to the telegraph companies." Are the new appointments not made under competitive examinations? What number of the old officers were retained?	Candidates are required to pass a qualifying, but not at present a competitive examination, before the Civil Service Commissioners. The majority of the old telegraph companies' officers were retained in the service of the department; in all nearly 4,000 were retained. At the present moment the department employs, in round numbers, about 8,500 clerks and messengers upon telegraph work.
"If the Government under this Bill obtain powers to acquire, work and maintain electric telegraphs, it must be understood that they must eventually become manufacturers and contractors." How is this matter of contracts? Do the contractors say that they get more or less now than formerly?	The department has not become its own manufacturer or contractor, and although the contractors have not been asked the question, there can be no doubt that the enormous increase in the number of poles, wires, and telegraph instruments, now used in telegraph business, has furnished them with much more work in this respect than they would have had under the old companies. The total number of instruments at the time of the transfer was 1,869; at the end of the last year the number was 7,542.

GEMS OF INDUSTRIAL ART.—TURKISH COFFEE SERVICE (CHAMPLEVÉ ENAMEL).

By Christofle and Co.

AMERICAN SOCIETY OF CIVIL ENGINEERS.

A REGULAR meeting of this society was held at the rooms in New York, March 19th, 1873.

Joseph Whitney, C. E. of Cambridge, Massachusetts, presented the subject of "Leakages in Water Pipes," illustrated by specimens of defective water pipes from the Cambridge Waterworks.

He desired to make a simple statement of his own operations and experiments. The great and growing increase in the consumption of water is a matter of the first importance in the management of waterworks. Scarcely a report relating to waterworks is issued which does not refer to it, and as something quite unaccountable; still no systematic effort is made to ascertain its cause.

Some years since his attention was called to the subject in Cambridge, where, for three years preceding, the water pressure had been growing less, thus causing much inconvenience and insecurity in case of fire. This was ascribed to the great number of users from one main, an eight-inch pipe. In a particular house the water scarcely rose to the second story, at night or day. After inquiry, a series of observations were made, with syphon pipe and pressure gauge, to determine the cause. These were made in the morning, when the consumption was nearly nothing; and in one case, by shutting off certain sections from the main, say a four or six-inch pipe, a large leak was revealed where the pipe, laid in a street filled with oyster shells, had parted. In another case, when the gate was closed, the water in the syphon at once rose sixteen feet—equal to about two storeys of an ordinary house; the pipe, about 600 feet long, and laid upon a mach, was examined, and the leak found in a joint where the two parts had been entirely separated by a settlement of one section. These and other leaks, detected similarly, were closed, and thus, without any increase of size in the main, an additional head was secured of 35 feet, which gave a full supply to each house in that locality.

Observations were afterwards made upon the water in the reservoir in the night-time, which showed still a leakage. By continued experiments upon the pipes throughout the city, nearly two hundred leaks, of from 1,000 to 2,000 gallons each per hour, were found. The necessary repairs were made, and thereby the average daily consumption per head was reduced from 85 to 35 gallons, which is not more than one-half that in most cities.

Leakage of this character may exist a long time without being known; thus, it may start when the water is first let on, and the water find a passage through some blind channel into the sewer; it will not be seen at the surface, unless thus upward and outward is the easiest course.

It is quite probable that this subject concerns other cities than Cambridge, and furnishes a satisfactory reason for the great increase in the consumption of water, and the corresponding growing demand for supply, which more or less embarrasses public authorities.

It is said that in the city of New York the consumption is about one hundred million gallons per diem; if so, he was sure at least fifty millions were wasted through unrecognized leaks into the sewers and surrounding rivers. In Boston more than seventeen millions of gallons are supplied where eight millions should suffice.

It is a fair presumption that one half these great amounts being but waste, its corresponding cost in the construction and operation of waterworks may be saved; surely examination, complete and exhaustive, should be made to determine whether this is presumption or fact.

Thomas F. Rowland, M. E., of Greenpoint, N.Y., presented a paper on the "Adaptation of Mechanical Power to the Work of Charging and Discharging Gas Retorts," illustrated by a large working of model machinery for the purpose, by which it is proposed to take the coal from a pocket outside of the retort-house, size, mix, transport and deposit it in proper quantities in the retorts and afterward discharge therefrom the resulting coke into the coke-barrows.

The apparatus consists first of an iron car, which traverses the retort-house in front of a bench upon a railroad of twelve feet gauge, and carries the mechanism for charging and discharging; and second, a series of buckets which, suspended from an overhead or "pendant railway," conveys coal to the charging apparatus.

The iron car, about fourteen feet square, is propelled by an engine and boiler placed upon it, which also drives the machinery carried. Midway on the car the meter is located which receives the coal from the buckets and deposits it in the charger.

The meter is a horizontal cylinder divided longitudinally into three compartments or cavities, such that each will contain enough coal for one retort. It revolves intermittently at the base of a hopper or "coal pocket," which receives the coal from the buckets, each cavity therein being in turn filled with coal and emptied by discharge into shutes, severally in communication with the three scoops of the charger. These shutes are placed one above the other, and as the meter revolves, are automatically opened and closed, so that the coal is discharged into each in succession. The edges of the meter cavities and of the throat of the "coal pocket" are armed with hard, sharp steel blades, to cut or crush fragments of coal which, lodging between the surfaces, otherwise might clog the machine.

The "charger" is a carriage traversing the top of the car transversely; its three scoops are placed one above the other at distances corresponding to the vertical measure between the retorts; they are D-shaped, like the retorts, and have moveable bottoms. When the scoops are filled, by a transverse movement of the carriage they are thrust forward into the retorts; the motion being reversed, the bottoms and then the scoops are withdrawn, thereby the coal is deposited evenly over the retort, and the scoops made ready for another charge.

The "discharger" is a carriage similar to the "charger." The two are placed at opposite ends of the car, and the meter between them. By an automatic device three hoes or rakes are simultaneously thrust into three retorts, dropped until they rest on the retort bottoms, and then withdrawn, whereby the coke is removed and discharged on to the retort-house floor or into coke barrows.

One tier of retorts may by be charged and the adjacent one discharged at the same, and in a very brief time.

The "pendant railway" consists of two single parallel rails, ten feet apart, suspended from the retort-house roof, over the railroad before mentioned, and connected at the ends by semi-circular rails, thus together forming an endless line, from which is suspended a series of coal buckets, attached to a flexible steel belt by which they are separated at uniform distances apart. The belt passes around horizontal drums ten feet in diameter, and placed one at each end of and below the line, their vertical shafts being in the centre of the curved rails. One of these drums is an idler—the other, that at the receiving end, is in a tower outside of the retort-house. In its periphery are two openings, diametrically opposite, which by two inclined shutes are connected there with a fixed cylindrical hopper or reservoir for coal above. The buckets are vertical cylinders, with one-half of the upper part cut away, so that when they are in contact with the drums their axial planes coincide with the periphery. The space between the buckets on the belt is equal to one-half the circumference of the drums.

When this apparatus is in motion the buckets pass along the "pendant" railway. Their openings are brought successively in contact with the openings of the drums, so that the coal conveyed by the inclined shutes from the reservoir drops through them, the quantity being regulated by valves in the shutes, worked automatically.

The buckets have hinged bottoms to drop downward, and are opened when passing over the "coal pocket" on the car, at the will of the operator, by releasing a catch; they are mechanically closed just before reaching the drum, where they are filled.

The coal in the yard, after passing between sizing and mixing rolls, is lifted to the reservoir over the drum, by elevators similar to those used at Messrs. Hecker's flour mills in New York.

The several parts of this apparatus can be worked independently, and thereby accommodated to the varying demands likely to be made upon it.

ASPHALT: ITS IMPORTANCE FOR STREETS IN CITIES AND TOWNS.

By Dr. L. Meyn.

THERE are but few natural and artificial substances capable of taking the place of asphalt for footways. Its peculiar advantages are possessed by none, and in regard of cleanliness not a single substance equals it. It has, however, been replaced in some towns by various other substances, owing to the shortsighted economy of town commissions and architects, who have been persuaded by the representation of the manufacturers of artificial asphalt; the result showing that the material only lasted some ten years, while if prepared from natural asphalt it

would have endured a century. The time has, however, arrived when such municipal councils should give more specific attention to the substance itself. A new epoch has arisen in the employment of asphalt in municipal public economy likely to lead to greater cleanliness both in the footways and carriage drives. The number of large towns has been greatly augmented by the influence of railways, and the traffic of these towns has greatly increased, the number of horses and carriages being not only absolutely, but relatively, more considerable in regard to population. The same cause has concentrated a greater amount of wealth in towns, and whole streets have started up where a handsome style of architecture has replaced the former kind of buildings, reared only for absolute need. Formerly Venice was the only city which displayed an uninterrupted magnificence in outline amongst private houses. At present city after city shows a gradual increase in the beauty of its streets, although perhaps not of so uniform a character.

Thus the requirements of society have transformed whole cities, or, at any rate, whole quarters of cities, from a loose agglomeration of separately built houses into a compact system of dwellings, connected closely by water, drain, and gas-pipes; nor is it perhaps too soon to expect that ere long fuel will be supplied in a similar manner. In such a complex system, our roadways may be considered to take part, standing in intimate connection with the houses, and protecting the subways in which lie imbedded the pipes for other purposes. With the exception of a roof, there is nothing to distinguish our roadways from the general mass of building of which they thus form an integral part. Up to the present time, however, very little care has been bestowed upon the formation and maintenance of the carriage-ways; for while such important cities as Paris and London have long since been obliged to give great attention to the subject, custom has hitherto regarded road-making in smaller places as a matter of the most everyday prudence, much to the disadvantage of those places.

At first, when cities lying in plains were at a great distance from quarries, the roadways were generally paved with stones taken from the beds of adjacent rivers, or belonging to the extensive glacial diluvium which covers the greater part of North Germany and many fertile tracts of other countries. But when it was resolved to replace these uneven lumps of such various size, recourse was had to the nearest quarries, and blocks of similar constituents, form, and shape were used to produce an uninterrupted roadway. The rule then was to select the largest blocks, and bury them deeply in the soil, thus securing greater uniformity and safety; but the result was, that every little inequality caused by the sinking of a large block at one corner produced a deep hole which struck the wheels, shaking the carriages, in turn breaking the edges and corners of the next paving-stones, and thus the large, strong, and expensive pavement, believed to possess such power of resistance, in a short time became as uneven as the former pavement of cobble stones.

The more prudent the road commissioners were, the more clearly they demanded—as, for instance, in London—a uniform size of four-cornered stones of small dimensions. These, as a rule, were found the most serviceable, and proved the best calculated to resist wear and tear. By these smaller stones the greater part of the noise of carriages was avoided, as well as many accidents to the horses, common enough on the larger blocks. Still, the evil was not entirely overcome; and in order to get rid of it entirely, macadamized roads, previously found so valuable on country high roads, were introduced into towns. It is not necessary to describe here the miseries of dust in summer and mud in winter caused by this unhappy system. Hence we may really regard it as a new era in the public economy of towns, that the railways, which brought about the necessity, also brought about the means of deliverance, by an increased facility in the transport of asphalt. In addition to this, the activity which has been created in this branch of labour, as we are about to show, may well be regarded as an epoch both new and brilliant in the industry of asphalt, so long partially forgotten and put aside. At present we shall present a brief history of the origin of that industry as perspicuously as possible.

In order, however, to spare our readers several errors and prejudices, we shall first try to explain the nature of asphalt as distinctly as we can. The prejudices which have arisen against asphalt in reference to this new employment of it, have chiefly been caused by the experience obtained in its use for footways. Where the latter have been made at no great distance from the sources of natural asphalt, we find no objections have occurred, as it is almost everlasting in its duration. But where it has been laid down at greater distances, *i.e.* where the natural substance has been enhanced in price by transport, it has been found almost entirely unavailable. The reason for this is very plain: for it is a very acute judge who can distinguish natural asphalt from artificial mixtures of tar, pitch, and chalk, &c., and inexperienced persons do not even perceive the important difference in smell, and thus in very many places an inferior material is often laid down as asphalt. The name has especially been misused by technicologists; as, for instance, in the case of paper roof tiles, which are generally only steeped in coal tar, and called asphalt tiles, and those pipes steeped in coal pitch, mere rolls of paper, are called asphalt pipes.

The industry of asphalt proper only demands genuine materials and skilled artificers. In many places, builders have been accustomed to use in the foundations of houses a mixture of tar, lime, and sand made by an unskilled hand, and dignify it by the name of asphalt. With such a mixture the same builders, no doubt honestly deeming themselves acquainted with asphalt manufacture, covered casemates and bridge arches. Here, therefore, we find bad materials associated with ignorance on the part of the workman. That which was invisible remained buried with all its errors; but when these blunderers essayed to pave footways, the mistakes came to light; hence it is not surprising that the substance fell into great discredit, and seldom, if ever, fulfilled the desired or expected conditions.

We hope in this essay to destroy many of the prejudices existing on the subject. But we have besides another duty: that of encountering a series of errors hitherto found among classes of architects, and which have been disseminated by the writers and teachers on the art of building-materials by careless and erroneous representations. In the books referred to, and which are received with respect on account of the authoritative names prefixed to them, the name of asphalt is almost always extended to these artificial blendes, although the latter possess very distinct qualities, often entirely opposed to the real substance from an architectural point of view.

It is easy to indicate the source of these errors. Only twenty years ago the then famous work of Accum on "Building Materials" contained no paragraphs respecting asphalt; and when the new name afterwards was adopted in architecture, the experts naturally drew their chief knowledge on the subject from the mineralogical authorities.

Mineralogy, however, from the first, understood by asphalt something quite different from the acceptation adopted by technology—meaning only mineral-pitch, or bitumen; therefore, when the characteristics and topography of this subject passed into technology, there was actually no real relation between the substance itself and those characteristics. Technology again understood by natural asphalt nothing else than porous limestone partially permeated by dense mineral pitch, capable of being worked up into a tough and hard mastic, while the pure mineral pitch, which is won by evaporation from earth-pitch, as a rule was only described as *goudron minéral* (Barbadoes pitch), and very seldom as asphalt. The mineralogists therefore heard with surprise of great reservoirs of asphalt employed in technology, and thinking that by this substance, long known to them as asphalt, was meant mineral pitch, they tacked on to their accounts of native mineral pitch, descriptions of such immense reservoirs, although as a rule scarcely a trace of the asphalt they described was to be found in them. Even Hausmann, of Göttingen, a most careful and attentive mineralogist, who was famed for his minute knowledge of all branches of technology, fell into this error, and thus this unfortunate misunderstanding was nourished by the most competent authorities in both branches of investigation. Authorities of the second rank, and compilers, it may easily be understood, added to this confusion by not only using the word asphalt in both senses, but, what was still worse, using them in a promiscuous sense. Thus asphalt was under an evil star, as its properties and advantages as a building material—not to be found in individual instances or by chemical analysis, but only by experience on a large scale—is only explained in fugitive circulars emanating from the owners of asphalt pits and asphalt factories, abounding in a certain partiality for the subject of the manufacture, and devoid of any strictly scientific sense.

Hence we are unable to find in the manuals of mineralogy and geognosy, or those of lithurgy or technical chemistry, any sufficient information on the nature of asphalt, its dispersion or manufacture, nor do the manuals of practical architecture supply any information respecting the imitations made of it, or any right appreciation of this valuable natural building material; indeed, we do not know of any work in any of these branches of science deserving of commendation. We have before us at the present time two recent manuals of practical building, both extremely valuable, one by Bernhard Grüber, architect, and professor of architecture at Berlin; the other by Rudolph Gottgetreu, architect, and professor at the Polytechnic School at Munich. Of the three hundred pages of the former, and the six hundred and sixty-eight pages of the latter, we find respectively not quite three and seven pages concerning asphalt, and even in these there is far more about the artificial blendes than the natural minerals, and the so-called mineral asphalt is called resin, and regarded as identical

with asphalt itself. Thus it is easy to see how mistakes, occurring in the best authors, may readily be found among less competent writers. It is by this very confusion that we may understand the universal discredit into which asphalt has fallen. When every pitch and resin is rightly distinguished, when artificial blendes are described as they really exist, and when asphalt mastic is understood to be melted mineral bitumen and bituminous stones, then it will be possible to name and use each material in a proper way. We therefore coincide with the method of the distinguished Léon Malo, who prefixes to his essays on asphalt in the "Annales des Ponts et Chaussées," 1861, a classification of the respective natural substances.

But we are inclined to differ materially from him in regarding coal and bituminous slates as a portion of the group of asphalts, his arrangement having been wholly founded on chemical analysis, and the amount of carbon, hydrogen, and oxygen contained in them. Coal naturally belongs, together with asphalts, to the class of combustible substances, but it is by no means of a bituminous character, any more than the unfortunately named "bituminous wood" (ligneous brown-coal), or the slates, only first really bituminous under distillation. Coal is the product of an immediate accretion of organic matter, which has to a certain extent conserved its outward and even inward structure. It forms with brown-coal and peat, both much more closely allied to it in properties and origin, a group of itself, and is specially distinguished by this very partial preservation of organic structure from those substances of a carbonaceous nature which have been formed from organic liquids. The circumstance that a part of coal—that used in the production of gas and coke—is susceptible of fusion, cannot be taken into consideration here, the conditions of origin being so distinct, especially as the so-called fusion of coal is not an actual fusion, but a process of segregation, as it is impossible entirely to re-fuse melted coke.

It is certainly not to be omitted that special kinds of coal from the recent secondary rocks, known as jet, which are manufactured in consequence of their want of structural form, resemble certain native mineral pitches, hardened to the greatest degree, to such an extent as to be almost indistinguishable. The instances in which there is any doubt whether mineral pitch or coal is present can only seldom exist, and then the mode of stratification is decisive.

Asphalt minerals, according to analysis and origin, are no other than oxydized petroleum or naphtha compounds. Their dispersion is hence analogous to that of petroleum; indeed, they are identical therewith, and are only distinct from this carbohydrate from their having subsequently absorbed a certain amount of nitrogen. That coal is also formed of carbon, hydrogen and oxygen, by no means entitles it to rank in this series of bitumina; for on the one hand it contains, like the plants from whence it arose, a proportion of nitrogen, and on the other, its oxygen has not been taken up in consequence of oxydation, but is only the remains of a greater mass of oxygen which existed in the organic flora, and has only partially disappeared in the form of carbonic acid and water, during the long subterranean carbonization of the vegetable mass. For the cardinal distinction between coal and the asphalts is, that the chief mass of coal is insoluble in all media, especially in ether solutions; whereas the whole mass of all asphalt matter, in so far as it does not consist of stone mixed up with it, is entirely soluble in ether solutions. The series of bitumina and bituminous stones, as given below, is hence perfectly intelligible. We have only to remark that the paraffin-like and crystallized carbo-hydrates belonging to the same natural family are omitted in consequence of their very slight dispersion, and are not specified, as it was only necessary to set forth the great natural products in their series. Nor is it necessary to enter upon the large field of petroleum.

The unmixed bitumina may be given in the following natural order:—

1. Rock oil or naphtha.
2. Earth oil or petroleum.
3. Rock tar or malth.
4. Earth pitch or asphalt.

Naphtha, formerly the rock oil of the apothecaries, is manifestly the source of all the rest. It is found in small quantities in almost all, and is the first to be separated by distillation; it flows from the earth in a pure state at but few places on the earth, and the classical neighbourhood of the Caspian Sea is the only district to be named. From its great volatility and the warmth of the earth's crust, it forces its way up through the rock in which it exists by distillation, and condenses again in other porous stones or in the mountain clefts, whence it flows in a pure state, or mixed with water. It was long believed to be a product of the distillation of coal at a great depth, but gradually, and especially since the discovery of the oil wells under the coal measures in America, a conviction has ensued that it is rather the distilled product of organic life, particularly animal life, spread in minute quantities in the rock, the only monuments of the flesh of innumerable generations of animals of the most diverse description.

As soon as it has been in contact with the air for any time it becomes greatly changed. It assumes a brown colour with a greenish tint, it grows thicker, obtains a higher specific gravity, and yields at low boiling temperatures only a slight distillation, a greater quantity of carbo-hydrates only at higher temperatures, in consequence of molecular condensation, and leaves behind a residuum, sluggishly fluid and of a tarry nature, containing a certain quantity of finely divided earthy matter. It is unnecessary to state all the sources of petroleum here, they are sufficiently well known in consequence of the mercantile importance of the article. We shall therefore merely name the places in Germany where it is found. These are:—

(*a.*) Tegern See (Lake Tegern), in Bavaria (Quirinus oil).
(*b.*) Bechelbronn, in Alsace (Hanau earth balsam).
(*c.*) Eiterfeld, near Fulda in Hessen (recently discovered).
(*d.*) Reichartshausen, near Darmstadt (recently discovered).
(*e.*) Peine, Verden, Edemissen, Oedesse, Hänigsen, Wieze, Steinförde, and Brunswick, where it is partly gathered from standing waters and sunk wells, and leads us to hope for still greater results.
(*f.*) Hölle, near Heide, in Ditmarschen, where at a slight depth a huge chalk formation, as full of petroleum as a sponge, containing 250 million cwts. of petroleum in the very small area yet explored, have been found.

Longer exposure to the air continues the metamorphosis, and the petroleum is changed into rock tar; indeed it is difficult to say where the line of distinction between these two liquids is to be drawn. The degree of viscidity observed in Swedish tar establishes its character as properly such, but the boundary line is quite arbitrary. Wherever petroleum exudes from the earth, and especially in places where it has been found from antiquity, rock tar is also found, for the oxydation of the oil by the air continues with regularity, and almost all petroleum sources and wells have been discovered by the presence of rock tar near the surface.

As a rule, almost without exception, the sandy strata are permeated by rock tar, and natural basins whence this matter freely exudes are very unusual. One region where earth oil is very common is in the volcanic district of Clermont-Ferrand, France; it is not only found in combination with the general mass, but in an actual spring, the Fontaine de Poix. Above the enormous petroleum centre of Hölle, near Heide, close to the surface, there is a bed of soft diluvial sand, twenty feet thick, entirely full of rock oil easily dug out with spades.

In the Hanoverian petroleum wells, from the sandy nature of the Lüneburg-Heide soil, a portion of the sand is almost everywhere thick with tar. In Alsace, at Schwabweiler and Bechelbronn and some neighbouring communes, a part of the tertiary sandstone is steeped in the substance in like manner. At Seyssel, in the department de l'Ain, the tertiary sandstone is bituminous by rock tar; and at Bastennes, in the department des Landes, a region closely resembling that of the Lüneburg-Heide, the sand has become bituminous, and for many years much rock tar was obtained there, and exported by way of Bayonne, until a falling off in the bituminous rock put a stop to it.

Pure rock tar is obtained from all these sandy masses by washing or boiling with water, causing the sandy particles to subside, the oil floating on the top. The rude matter is then heated again to evaporate the water contained in it, and separate any further particles of sand. According to its density, the rock tar is then either heated in open boilers for a certain time to drive out the volatile oil, or distilled in retorts in order to win it, and the result is then a specially dense brilliant black pitch superior to every other kind of pitch. Although this may be called an artificial product, from the process of evaporation to which it has been subjected, it is in fact the very substance known as viscous earth pitch, or viscous asphalt. In the manufacture of asphalt this product, under the name of *goudron minéral*, forms the best basis of value, and the fused material for the liquidation of the ordinary rock asphalt in the form of mastic.

But the rock asphalt, to a description of which the following pages are devoted, is really only a limestone, inspissated, like the sand, by rock tar. Its constitution differs slightly from that of the sand rock tar, its viscidity being greater. But this is probably only apparent. Such an intimate blende is very usually found naturally produced. The limestone of the new conformation at the Val de Travers is the best instance of this. The next quality may be found in the rock asphalt of Pyrimont, near Seyssel, on the Rhone, and in the neighbouring places, Volant and Chavaroche, whence it is procured by mining. All these are limestone of the upper or white Jura formation. Both of these we shall very fully describe. Next to this comes the bituminous limestone of the Alpine lias, found near Seefeld, in the Tyrol, in many quarries, and the tertiary sweet water limestone of

Lobsan in Alsace, where mining is resorted to. Then follows the yellow-white Jura limestone of the Island of Brazza, Dalmatia, the dolomitic banks of which, for a thickness of twelve feet, contain 7 to 8 per cent. of bitumen, and hence are quarried out.

A veritable asphalt limestone is found at Limmer in the pterocerene strata of Kimmeridge Jura, close to the city of Hanover, and it is also important that a few years ago a similar rock asphalt was found in Brunswick-at-Holzen in the Hilsgebirge, to the east of Eschershausen, and now known in commerce as the Vorwohle asphalt, from the name of the nearest railway station. This also comprises a Jura limestone stratum of the upper series, somewhat more recent than that at Limmer, and belonging to the so-called Portland strata.

But the largest source of this kind is the before-mentioned bituminous chalk limestone rock at Hölle bei Heide in Ditmarschen. The bitumen, however, here, although as intimately combined with the limestone as in the classical regions of its great abundance, according to the results obtained by the Paris *Compagnie Générale des Asphaltes*, contains too much pure petroleum for immediate use, in consequence of its lying so much further beneath the surface, there being 120 feet of diluvium above it. It is for the future to teach us when the stone, on being raised to the surface, may lose by exposure to the atmosphere and oxydation some part of its petroleum, and thus yield perfect asphalt limestone, whether more rock tar and less petroleum will present itself, or whether the tar contained in it can be concentrated during manufacture on some part, while the oil is removed. In case of this being so, this single source would be sufficient to furnish all the great cities of Germany with asphalt roadways. The chemical constitution of asphalt, &c., shows that it would be possible to extract a part of the yet unoxydized carbo-hydrates. By different modes of solution or different temperatures, asphalt, rock tar, and the allied bitumina are converted into other forms, very variable in their nature. Individual analysis in this direction is only specific, and only generic by its qualitative nature. Boussingault, who possessed some land near Bechelbronn, especially busied himself with the chemical nature of these substances.

All carbo-hydrates, described as petroleum and naphtha, are given off at about 200° Celsius ; from 200° to 250° Celsius an oil is developed—the last liquid form of rock tar—called by Boussingault petrolene. After it has been kept for days at a temperature of 250° without any apparent diminution of weight, a substance remains, heavier than water, easily breaking at a low temperature, and called asphaltine—that portion of the bitumen insoluble in ether, and only soluble in turpentine and similar solvents. Petrolene has also been divided into light coloured and dark coloured, the first of which is soluble in pure alcohol, but the latter is not. The last might be properly called malthene, to preserve the parallelism of the terminology. For technical purposes a mineral oil, or earth-pitch, would never be named after this analytical method of chemistry, for in the important properties of viscidity and relative degrees of fusibility, it will constantly be necessary rather to fix these points by direct technical observation, than by the somewhat treacherous indications of them furnished during chemical analysis.

The mineralogists may be considered to find their asphalt in mineral tar, and the mixtures of mineral tar with stones of various kinds. But this also comprises several substances within itself, some of which are hard and brittle and some soft and viscid, some again absolutely free from any foreign mixtures, and others drenched with earthy particles. It is found in the purest condition in small cavities of old stones, in druses and crystallized holes, whither it has shed itself drop by drop, or reached by evaporation ; somewhat less pure in clefts of stratified rocks, as in the chalk near Münster, and in actual ore formations where it partially protects the crystals by a rim.

An extensive stratified deposit of real asphalt is very seldom to be found. We hear something of such a deposit in Klaproth's statements concerning Avlona, in Albania ; the so-called asphalt lake in Trinidad is also known ; and we are told of its presence in the Dead Sea—a circumstance, like most other East Asian products, coming as they do partly from the East Indies, partly from Aleppo, through Trieste, into commerce—of a doubtful and traditional character, like all the tales promulgated by the shippers, and not confirmed by observations made on the spot. The Greek and Roman historians commenced the fable concerning the Dead Sea, by relating that asphalt floated about in it like small islands, supported by the nitre held in solution by the water ; the Biblical story of Sodom and Gomorrah afterwards caused these representations to find credence, and through the whole of the middle ages and modern times the legend of the enormous asphalt deposits of the Dead Sea, as a legend, has continued. The naturalists, however, who some years since explored Palestine, have discovered that this description is at least unfitting at present, and that at long intervals, caused by earthquakes, asphalt is occasionally projected from the bottom of the Dead Sea, and is then thrown upon its shores. But this so-called Jew pitch, and in fact all the Oriental or Egyptian asphalt, is very pure and expensive, and, indispensable in the preparation of certain varnishes, is entirely useless in the proper manufacture of asphalt, from its brittleness and also—its price in the market.

The asphalt-lake of the island of Trinidad is far more important. This island, situated at the mouth of the Orinoco, contains a real asphalt lake, more than 1,000 paces long and 120 paces broad. From this lake pitch-rivulets have flowed similar to lava streams, and formed reefs in the ocean in like manner. This lake is reached by pitch-reefs and pitch-pathways, only three-quarters of an hour from the west coast, exhibiting a bare black surface amidst the most luxuriant vegetation.

The asphalt is sufficiently congealed at the edge of this lake by oxydation, and also by the slow distillation of the oily matter under the sun's rays acting on the black surface. But in the centre of the lake the sun continues to fuse the mass, and it is only during the rainy season that it is possible to traverse the whole extent of the surface. Clay, from its former fluidity, has been taken up in certain quantities in this Trinidad asphalt, from which it is freed by fusion to the highest degree with bituminous oils, and allowing the sediments to settle at the bottom for removal.

Another great centre of considerable production, most important for manufacture, is the island of Cuba. This is commercially termed Mexican asphalt (*Chapopote*) ; but it is known that it comes from the island of Cuba, and especially from the vicinity of Havana, notwithstanding that the strata have hitherto been very little known. The best hard Chapopote asphalt yet contains 27 per cent. of clay or earthy matter, as the Trinidad asphalt does, the inferior sorts having at least 35 per cent. of clay. There is, however, a very viscous mineral oil obtained thence (under the same name), which is distinguished by a very great degree of purity.

The places in which asphalt is found in Asia being left out of question, although their topogeological history should not be neglected, we find ourselves reduced to a very few sources, the so-called bituminous shales being scarcely worth consideration, the bitumen in them not being completely formed, and rather useful in artificial blendes than otherwise, the asphalt being deteriorated by their oily nature. Basing ourselves upon the foregoing classification of *natural* bitumina, we can now proceed with greater confidence to the historical development of the industry of asphalt.

It has ever been necessary in Middle and Northern Europe, owing to its variable climate, exhibiting periods of uninterrupted rain and even snow, that the inhabitants should take extreme precautions in the construction of their houses against damp and damage by water. The art of decoration offered by architecture as a means of beautifying dwelling-houses has been much impeded by this stern necessity. The Gothic system of architecture, which spontaneously arose under the influence of the Western European climate, and in which this disadvantage was kept in view from the first, has alone admitted of a free development of its peculiar architectural beauties. This system, however, is little adapted for smaller structures, and can only be applied in buildings of a larger kind.

As long as the homely citizen's house was sufficient for the well-to-do in all these regions, it was not difficult to provide for the necessities of building in these respects. But when a nobler culture and a greater degree of luxury refined the higher classes of Europe in the era of Louis XIV., and thus increased their requirements—when houses built after the style of southern climates, together with places of amusement, were introduced, and even new forms were invented—watertight materials for roofing were required in quantities unknown in the south ; and besides plates of copper and lead, the price of which was high, and which, when combined with visible portions of the structure, often destroyed every beauty, roofing and binding materials of a resinous character—the mastic preparations, in fact—were used well adapted to resist the action of water. Strangely enough, the more eminent builders never thought of using asphalt and mineral pitch, although its existence in Europe was known, and had even been employed in some degree.

It was known from ancient authors that Babylon—the buildings of which had a renown of four thousand years—had been partially walled with asphalt; but the fact seems to have been confined to learned circles, and as it was never found in the structures of the Greeks and Romans, taken as patterns, the Babylonian use of asphalt described by Herodotus, Strabo, and Pliny, fell quite out of notice. From the statements of recent travellers it appears that Nineveh was also built with asphalt mortar, and that the asphalt mortar used in the walls of Babylon

was derived from a mineral oil dug out at Is, on a tributary of the Euphrates.

The first person who presented modern Europe with this admirable building material was a Greek physician named Eirinis, about 1712, and he subsequently distinguished himself by the discovery of mineral tar in Alsace, in 1735. In his official capacity as an expert under the Bernese Government about 1711, he visited the Val de Travers, a valley leading from the Jura mountains to the Lake of Neufchatel. Here he met with a German adventurer named Jost, who in company with a few fellow-countrymen had blasted from the rocky walls of this valley a heap of stone, the nature of which was partly combustible and soft, so as to be easily worked, but which being unfit for fuel, they sought in vain to convert to some useful account. Interested by the circumstance, Eirinis examined the sides of the valley minutely, and discovered that this soft and greasy stone was everywhere to be found, and brought to light the fine quarries in the neighbourhood of Bois de Croix. What, however, was of greater importance, he recognized the utility of the stone for building, and the possibility too of turning it to technical account. He therefore addressed himself to the King of Prussia, then Lord Protector of Neufchatel, and asked for a concession of all the asphalt beds to be discovered in the principality of Neufchatel. The King referred this petition to the Council of State of the Principality, and after a careful investigation the worthy man was granted the concessions with some few conditions. From this concession has arisen the whole of the industry of asphalt.

In the year 1712 Eirinis therefore began his labours and experiments, in order to put the proper application of asphalt on a firm basis, and induced men of recognized ability to interest themselves in such a way as to undertake buildings according to his instructions, and thus the matter gradually found acceptation and approval. His discoveries and inventions were laid down by him in several pamphlets, which do not seem to have much varied in their contents, appearing first in 1721, and then in a later edition in 1784. The fullest title of one of these is as follows :—

"Dissertation sur l'asphalte ou ancien ciment naturel découvert depuis quelques années au Val de Travers dans le comté de Neufchatel, par le Sieur E. d'Eyrinis, professeur de grec et docteur-en-médecine, avec la manière de l'employer tant sur la pierre que sur le bois."

As Dr. Eirinis is to be regarded as the true discoverer and inventor of modern asphalt technology, and as his enlightened activity in this field has prepared the present triumph of the subject, and may be regarded as its foundation, it is worth while to make the labours of this inventor known to greater circles. We cannot do this more satisfactorily than by quoting some notices on the preparation of asphalt from his above-named works, given by the mining engineer Henri Fournel, in a pamphlet on the asphalt of the Val de Travers, published in 1838 :—

"The author, who, during his many journeys, extending over years, has had occasion to perfect his knowledge of all kinds of minerals, has obtained from several reigning princes, but in especial from his Majesty the King of Prussia, very extensive and very favourable privileges for the continual use of the pits discovered by him in the lands of the said princes ; and as, with the aid of God, he found certain rocks in the principality of Neufchatel, containing a veritable asphalt, in every respect as good as the asphalt of Babylon or from the valley of Siddim, so famous among the learned, and has obtained a good quantity thereof, he found it worthy to acquaint the public therewith by these few lines until he shall have published his work entitled, '*Asphaltasphaliæ sive invertibilis bituminis veritas ac securitas.*'[1]

"As this asphalt consists of a mineral, clayey, and warm substance, which is more clammy and viscous than pitch, with fewer pores and very firm, as may be seen by its specific gravity, it withstands all influences of the air, of cold, and of water, insomuch that it cannot be penetrated by the latter. It therefore is better fitted than any other substance to bind together all kind of building work, or to be painted thereon, for it protects wood from rottenness, from worms, and generally against all the destroying influences of time, and, moreover, in such a degree that though it be continually exposed to water, air, ice, and every climate, instead of suffering from it, it becomes thereby, so to speak, indestructible. From this it is to be easily concluded that this is a natural cement, very proper for the binding together of wood, stones, and other substances, used for bridges, wells, ships, and other structures exposed to moisture.

"In various parts of Burgundy, Neufchatel, and Switzerland, the utility of this asphalt cement has been recognized by using it for cementing or tarring a number of stone and wooden buildings exposed to the action of water. The experiments have always succeeded well, and the author could, in case of need, produce a large number of witnesses to the fact. It is not to be doubted that as soon as this substance is better known in the world, all those who have the care of buildings will use it ; and this not only on account of its excellence, which is not inferior to, nay, surpasses all other sorts of cement, but by reason of its easy preparation, and because it is cheaper than any other artificially prepared cements. The preparation of the cement is very easy ; the stone is taken just as it comes from the quarry ; it is slightly heated in order to rudely break it to pieces ; a small quantity of pitch is added that it may melt more easily, and render the mass thinner ; it is then melted up by a gentle coal fire.

"The wood or stone to which the cement is to be applied should be carefully dried and slightly warmed. For stone cement, until now, one pound of pitch has been mixed with every ten pounds of asphalt ; but for wood cement more pitch is added. As to the degree of heat, it must be left to the workpeople, who will fit the needful temperature to the nature of their work ; it is enough to add here that the asphalt will become softer and more pliable the more it is melted up, but at each fusion some more pitch must be added. This re-fusion is effected in a copper vessel containing a quantity proportionate to the work in hand.

"*Observation.*—The pitch must first be melted and the asphalt gradually mixed with it, and this mixture continually stirred with a stick or spatula until the two substances have become thoroughly intermixed. The resin makes it harder, and better able to withstand the heat of the sun. The Dutch pitch obtained from tree roots makes it tougher. The mixture should consist of one part of common pitch and eight or nine parts of asphalt, according as it is wished it should be more or less liquid. After this process, before it is quite cold, the cement can be very easily smoothed by means of a warm iron, similar to those used by masons in brickwork.[1] Before all things the labourers should take care to cleanse the stone or other material before the cement is applied ; for if imperfections be found in the work, they would arise, not from the substance thus applied, but the careless method of applying it.

"It may be further remarked that the asphalt cement used in wells, if removed after many years, may be re-melted, and that this new fusion will cause it to become finer and stronger for the same purpose, the pitch which has been mixed with it previously having thus been preserved. It will not be difficult to convince the public of this fact when it is remembered that asphalt has been used for mummification and for the preservation of other bodies more liable to corrupt than pitch itself.

"Should any bubbles be formed by the cementing of wells, or empty spaces present themselves, it is easy to remove these in places where it is visible by gently rubbing the parts with some cold substance while the matter is still warm, and a further application of a red-hot iron rod, immediately effacing all inequalities, and causing the surface to become as smooth as a mirror."

These public statements on the use of his invention were supported by Eirinis by official documents dated in the years 1716 and 1719. In the first he is informed from Neufchatel that from 1714 to 1716 numerous cisterns and fountains of wood and various stones were all perfectly well mortared and bound in a permanent way by his asphalt, and that a platform and the floor of a granary were laid down to the satisfaction of their owners. In the second, coming from Basle, it is testified that with the asphalt cement he had so firmly united two pieces of hard rock, that when thrown from the window of a very high building on to the pavement it had not separated. He had also thus cemented two portions of a pillar of one foot in diameter and four feet in length, and in a quarter of an hour after the process it could be lifted and carried by both ends, and when finally cool was thrown on the pavement without breaking. Those who are acquainted with the superior applications of asphalt cement will see nothing very extraordinary in this ; but it is mentioned in order to show that Eirinis was no visionary, nor did he seek to recommend his new discovery by extravagant statements.

We learn from a note from the engineer, Henri Fournel, how admirably the disciples of Eirinis mastered the application of the material. M. Fournel relates that he had found at the house of a M. Coulin, in Couvent, one of the pretty villages of the Val de Travers, a staircase belonging to that period. All the steps of the first flight are of stone covered with asphalt some six to eight lines thick, and these, without exception, are in perfect preservation, while the steps of the second flight, which would naturally have not been so much in use, consist of stones unprotected by

[1] This work probably never appeared, although a controversial article respecting the title, against an article of the *Journal des Savans*, afterwards was printed at Besançon.

[1] Technically, similar to plasterers' hand-floats.—ED.

asphalt, and are worn into deep fissures by the feet. This testimony in favour of the workmanship of the school of Eirinis is far better than that of the sealed documents, now long since lost. Practical men acquainted with the art of asphalt industry cannot but remark with surprise how instinctively this skilful Greek physician seized upon the highest method of adapting the material for use, and organized it in a manner exactly the same as it is now used with all our advance in the technical arts, with the sole difference that instead of the Dutch (or really Swedish) pitch, the natural mineral tar, *goudron minéral*, is now used, on account of its superior density. Like other discoverers, however, Eirinis himself reaped little advantage from thus restoring to the world a building material forgotten by it for some four thousand years. A M. de la Sablonnière, treasurer of the Confederation, went to France to value the matter there in conjunction with the discoverer. When he had succeeded in this he neglected the originator, announced himself as the inventor, was recognized and honoured as such, and thus gained his immediate object. At his petition a royal privilege was granted him, dated the 21st February, 1720, to the effect that for ten years he should have the monopoly of importing the asphalt of the Val de Travers into France, to manufacture and to sell it without any customs' duties or royal taxes, and in such manner that no merchants' guild could interfere.

Buffon informs us in his "Natural History," that he made use of the asphalt of Neufchatel in the Royal Gardens, afterwards the *Jardin des Plantes*, and had a large basin covered with it. He was convinced of the durability of the work, for at the time of his writing thirty-six years had elapsed, and the basin was perfectly watertight. This structure, as the records show, was completed in 1743, therefore the asphalt of the Val de Travers must still have been in use at that time. But the employment of it must gradually have declined, for in 1735 Eirinis had left the Val de Travers and Switzerland, and settled in Alsace, where, living in retirement, and fortified by his previous experience, he discovered the asphalt pits of Lobsan, which have continued to be worked to the present day.

The asphalt quarries of the Val de Travers in many cases fell into other hands. Various private individuals successively owned the concession under varying conditions, and for shorter or longer periods. Gradually the industry created by Eirinis fell off, probably in consequence of the great expense of transport ; the oils existing in the asphalt were alone distilled for the purposes which the medical knowledge of Eirinis had pointed out, and from which branch of the industry an enormous profit could be reaped by practising upon the credulity of the sick. Thus it happened that the fame of the Val de Travers and its asphalt survived only in a few learned works, and that the discovery, together with the discoverer, were entirely forgotten in industrial circles towards the beginning of the present century.

In 1802, south of Geneva, at Seyssel, on the frontiers of France and Savoy, there was discovered a centre of rock asphalt, which soon became used for similar works to those of Eirinis, although the latter was unknown to the persons interesting themselves in the matter. For a very long time mineral oil had been seen at this place. It was found in a sandstone which is very common through the Rhone countries. Its strata lie almost horizontally in the Rhone basin, and rise some 200 to 300 metres above the river level. Throughout the whole region as far as Geneva, as far as the river Rhone from the frontier between old French territory and Savoy, it is bituminous in isolated spots. As in all other places where bitumen is found in sandstone, and not in sand, it is very irregularly distributed, as the hard or soft conformation of the stone admits of its absorption by capillary attraction. This bituminous portion of the sandstone was and is obtained in those banks at about the level of the valley by running in galleries, the irregular course of which follow the actual bitumen beds, the stone being taken out by boring and blasting. This bituminous sandstone is broken up, boiled with water for hours, then skimmed, and the mineral tar thus skimmed off again boiled to separate it from the suspended sand, which sinks to the bottom, and by evaporation it is freed from the water contained in it. In such an awkward process, perhaps three to four per cent., and often only two per cent. of the weight of the sand, was obtained of mineral tar.

A branch of industry of such a wretched and expensive nature received a new breath of life on the discovery at the beginning of the century of a limestone rock belonging to the Jura formation above the quarries, which contained 10 per cent. of bitumen. Although the superficies was very much smaller, it appeared from the strength of the outer unstratified mass to offer an inexhaustible material for industrial enterprise, when the method of preparing a mastic from the meal of the bituminous limestone, with an addition of 5 to 10 per cent. of mineral tar, had been discovered.

The application of this product at Seyssel—regarded as something quite new and extraordinary, as no one had heard of former experiments—did not proceed in the simple way which Eirinis had adopted ; but after some preliminary and very successful trials, asphalt was declared to be good for all sorts of things, and was lauded in the most extravagant manner by some, and accepted by others with unusual readiness. Reaction could not be long in setting in, and scarcely had the Seyssel asphalt come into fashion, ere it became an object of universal ridicule and contempt.

One after another the inventors were ruined, it being easy for an intelligent man to become convinced of the multiplicity of uses to which asphalt is applicable, but very difficult to induce a similar conviction in the minds of the prejudiced many ; and still more onerous is the task of overcoming the opposition of technical builders, who find themselves thrown out of their groove by the introduction of such a new material, and even if compelled to use it by the orders of the masters, they always bring it into disrepute by an ignorant and blundering employment of it.

At the end of twenty years the whole matter was so ruined that the quarries and factories at Seyssel at length came to a total standstill. About 1832 Count de Sassenay bought the property in its ruinous condition. It was owing to the conviction that the industry of asphalt had still a brilliant future before it, that the Count ventured to take up an enterprise in such entire discredit, and invest new capital in it, after two years' total inactivity at the works. But by this Count de Sassenay became the second founder of modern asphalt manufacture, and deserves to have his name mentioned beside that of the Greek Eirinis.

On an examination of the reasons for the failure of the Seyssel asphalt, the Count speedily saw that the chief cause lay in the wrong application of the product, which, badly utilized in foreign countries in unskilled hands, caused the material to be discredited instead of the persons carrying out the works. To this aspect of the question the Count therefore turned all his attention. By experiment, he ascertained the best method of using asphalt to be that of a fusible mastic, and by making slight changes in the process—apparently of the minutest kind—he effected great improvements. He also turned his attention to the sole application of the natural substance, and put aside all the other fanciful projects which had wasted the means and time of former inquirers. He also erected a factory for the study and proper fabrication of asphalt, and all the works ordered by Government were exclusively conducted by this establishment, and by labourers specially educated for the purpose. In a few years the reputation of the substance had entirely changed. Great market places and public halls were laid in asphalt cement, and all the fortresses of France were protected against damp in the principal parts by coverings of asphalt. At this time was constructed the well-known footway of the Pont Royal, and the fine asphalt pavement of the Place de la Concorde in Paris, the footway of the Morand Bridge at Lyons, and the coverings of the casemates as well as the interior walls of the corridors and magazines in the fortress of Vincennes.

These circumstances gave the French their superiority in the industry of asphalt which they have maintained above all other nations to the present day, a superiority they are likely to retain for a lengthened period ; and they may with justice name Count de Sassenay as the founder of their pre-eminence in this branch of manufacture.

It was in Seyssel or Pyrimont that the improvement over the system of Eirinis was made, already mentioned, *i.e.* the substitution of natural mineral tar for ordinary pitch. Local advantages brought this to pass. Had there been mineral tar in the Val de Travers, the invention no doubt would have been made there. But in Seyssel mineral tar had long been known and used before the rock asphalt was discovered. It was almost a natural circumstance that the viscous mineral tar of the neighbourhood should be used, instead of importing pitch from foreign countries ; but that it was in itself an improvement was not observed until experience had shown such to be the case at a later time. But a second improvement in the manufacture is to be ascribed to the local position of Seyssel—the addition of rough sand to the composition.

The river Rhone carries down a sharp sand of various grit, and it was not too far away to induce the trial of mixing it with the mastic. It was soon found that instead of deteriorating the mastic it improved it, in the same way as in lime or cement it gave greater firmness and resistance. Experience soon showed in what proportion this sand should be used, from a tenth part to a fifth being found the quantity. This materially reduced the expense of the asphalt composition, especially in sending it abroad.

Greater attention was now given to the capabilities of asphalt, as foot pavement, than when it was only confined to the cementing of moist walls. In pavements where the wear and tear is considerably increased, the firmness now obtained by the

admixture of sand told greatly in favour of its use. It was also found that if the surface while yet soft was strewn with fragments of the size of peas and beans, this again materially decreased the wear and tear. It is not certain whether these improvements are to be ascribed to the Count de Sassenay. It is sufficient to say that through him, and under his management, the Seyssel asphalt obtained a world-wide celebrity, and has been used everywhere with the greatest success.

The cities of France furnished the greatest market for this industry, especially Lyons, favourably situated near the quarries of Seyssel, and next Paris. But in England, North America, and Russia, asphalt has begun to be used in great cities; the terrace of the Imperial Palace at St. Petersburgh is laid down in asphalt.

As Portland cement has entirely supplanted asphalt in all architectural and hydraulic works, it is unnecessary to dwell upon the very slight part which the Seyssel asphalt has had to play in such undertakings.[1] It was never in any degree considerably used; the great consumption of asphalt has been for pavements and terraces over low structures or cellars.

M. Léon Malo, an engineer to whom I have before referred, has truly said that until asphalt came into use it was idle to talk of footways. The passenger-way beside the houses was generally paved with the small sharp stones which appeared useless for the carriage road; or in places where flags of slaty rock could be obtained, these were put together in an irregular and uneven manner. Asphalt, which came to smoothe away all these inequalities, has therefore been a real boon to cities; and no one need be surprised that on its introduction in 1837 it received the heartiest reception of the inhabitants of the towns, and was used in the most extensive way.

The mode in which the asphalt pavement is laid has remained very much the same from the first, but, instructed by experience, greater care has been exercised in laying the substratum upon which the asphalt is spread, as well as in the fusion of the composition itself. By the kindness of the Paris *Compagnie Générale des Asphaltes*, the author is enabled to describe the present process adopted by that body in the fullest way.

As to the preparation of the foundation, asphalt is only laid upon such a bed as is free from any inequality where water might accumulate. It has often been attempted to lay the asphalt direct upon a sand foundation, or upon flags and slabs, but this has nowhere succeeded, a much quicker deterioration always taking place by the starting of the subway. A foundation of béton has been found the best. It is desirable that this should be even in all ways, in order to receive a uniform coating of asphalt, by which the duration of the pavement is prolonged and the expense decreased. The asphalt can only be poured on to the béton when the latter is perfectly dry, or the superfluous moisture of the mortar evaporates and causes holes and bubbles in the pavement; the firmness of the béton is also endangered if it be covered too soon. Of course, in order to hasten the consolidation of the béton, hydraulic lime or cement is used. The mastic is brought from the factories in round cakes weighing 25 kilogrammes. These are broken up into pieces of the size of road stones, and are melted down in the cauldrons, the whole mass being distributed in three equal portions. A small quantity of bitumen is first melted in the cauldrons, being half of the entire mass to be used, weighing five or six per cent. of the weight of the mastic. A fourth part of this is set aside for finishing, in case the broth becomes too dry during the operation. The fire is kept at a uniform heat, so that the temperature is always over 150° Celsius and under 170° Celsius. When the whole of the mastic is melted and easily stirred, the molten mass in the cauldron is covered with half of the coarse sand to be used, in quantity 60 per cent. An interval now takes place, in which the heat is continued, but the stirring is suspended, until the sand begins to sink by its own weight, and the black liquid is seen here and there on the surface.

This caution is very necessary, in order that the sand may be dried and so far warmed that it should not cool the under part of the asphalt broth. The second part of the sand is added in a similar way. On the addition of this second part it will be seen whether the mixture is sufficiently prepared, and whether it is requisite to add the whole or any portion of the bitumen which had been set aside. On the composition appearing equal and perfect, and the heat we named above has again been reached, which is practically ascertained by squirting a few drops of water on the surface and observing whether they evaporate again with crepitation, and that the stirrer on being inserted can be easily removed without anything clinging to it, it may be at once applied.

Should the stirrer not go into the mixture easily, some bitumen must be added, the stirring being continued during the time; an interval should here be allowed to elapse until the temperature is regained. During the process of ladling out the mass must be occasionally stirred, in order that the sand may not sink to the bottom. The spreading of the mastic is effected by means of a wooden trowel of a peculiar shape, which is heated to a great heat in order that the asphalt may not cling to it. The asphalt is poured from great ladles on the places where a junction is to be made, to bind the edges together and cause a constant adherence. Without this precaution the various strips of melted matter will weld in an imperfect manner. In order to produce all the conditions of solidity and durability, the spreading of the mass must be effected by swift pressure. The use of this spatula is not easy, and requires considerable practice on the part of the workman.

In most cases the sand-layer subsequently put down, unfortunately for the general effect of the process, is limited to a mere sprinkling of the surface with sand. The object of this operation is not only, as many seem to think, for the production of a rough surface, but to give the uppermost stratum of the asphalt its necessary amount of sand. The sand usually sinks, in consequence of its specific gravity, so far into the mastic, and the purer mastic rises to the top. It is to fill this upper layer that the sand is introduced, for without it the sun would act upon the upper layer, and by softening it, cause rapid disintegration. The workman, therefore, should spread plenty of sand upon the stratum, fully to dry the mass, and a uniform amount of pressure should be applied during this operation, thus incorporating it with the whole mass. The thickness of pavement in Paris is usually about 15 centimetres. In 46 kilogrammes of mastic it is calculated there should be 3 kilogrammes of bitumen, and 30 kilogrammes of washed, sieved, and dried sand or gravel.

At one time the asphalt mixture, to prevent its cooling before use, was melted at the place where the pavement was to be made or repaired, in cauldrons with special furnaces. But many persons are annoyed by the smell of the asphalt, although to as many others the odour is agreeable, and in any case the assemblage of a large mass of material, and the boiling in the streets, would materially interfere with traffic. Therefore at the present time, in some places, and especially in Paris, where it has been rendered obligatory, another method has been adopted. The asphalt is melted down in the factories, and transported to the scene of action on wheeled carriages.

The absolute duration of a well laid asphalt pavement is not yet known. Several are known, laid some thirty years after the beginning of the century, which have not lost more than the thickness of cardboard during the time. Such well preserved pavements of that early epoch are to be found in the Place des Célestins, the Place des Terreaux, and the Quai de l'Hôpital at Lyons; but as a general rule the duration of a pavement of 15 to 20 centimetres may safely be estimated at from 20 to 25 years.

The great advantages of this pavement, its evenness without slipperiness, its relative softness to the foot, combined with great resisting power, its impermeability to water, by which the foundation walls of the adjacent houses, and their kitchens and cellars, are fully protected, and the absence of joints, must be evident to everyone acquainted with the old paving.

In consequence of the immense demand, the Seyssel works soon found rivals, and in Alsace especially, another similar industry was commenced.

At Pechelbronn (Bechelbronn) and Lampertsloch for years there had been known a kind of tar-oil floating on the surface of fountains, which had been used for medicinal purposes in many ways, and enjoyed a great celebrity. Rock containing bitumen was first discovered in 1735, and by the same Eirinis who discovered the Val de Travers, he being in that year resident as a private individual in the neighbourhood at Markweiler. What he discovered was the head of a lode of bituminous sand, belonging to the tertiary formation, and spread through the Vosges. Eirinis obtained the right of using the sand, and distilled the oil from it in a small laboratory which he built at the edge of the forest; apparently his object was medicinal. The business could scarcely have been profitable, inasmuch as he died without property, and his concession fell to the same M. de la Sablonnière who had reaped the profits of the Val de Travers. It is possible that the mineral tar obtained here may have been employed by the latter, without it being known, for the perfection of the Neufchatel asphalt cement. He certainly at once founded a factory for the production of mineral tar in the stratum of bituminous sand, the process being similar to that adopted at

[1] These are, of course, the opinions of Dr. Meyn. In a subsequent article, from the experience of other persons, it will be evident that asphalt may very advantageously be employed in important architectural undertakings. It must be remembered that Dr. Meyn thinks only of causeways. The experience of London is divided upon this point. The conductors of the "Practical Magazine" desire to be fair to all parties on the question. K. R. H. M.

Seyssel. The profits do not seem to have been large, and the association formed by his widow with a M. Le Bel does not appear to have succeeded.

In 1768, however, Madame de la Sablonnière ceded all her rights to her partner, and his family long remained in possession of the mine and factory, which at length began to show a profit. Although situated in Hessian territory, the factories of M. Le Bel enjoyed the privilege of a free introduction for the product into France; and when a new shaft was opened in 1785, an exceedingly valuable property was created; and although it sometimes assumed other forms, the works were from that time uninterruptedly carried on.

About this time a brown-coal stratum in the adjacent village of Lobsan began to be worked, and great quantities of it discovered, upon which the owners and managers of the neighbouring saltworks of Sulz, after complying with the necessary formalities, entered upon the business. Among these the saltwork manager Rosentritt became prominent by utilizing the bituminous sand accompanying the brown coal, and by the discovery of a little-used bituminous limestone. After the termination of many changes of ownership, caused by the revolution and the war, he agreed with the heirs of M. Le Bel to work all bituminous quarries in common.

These heirs of M. Le Bel do not seem, however, to have possessed much business capacity, for after imitating the Seyssel works on their own estates from 1817, they became bankrupt in less than a year, and in 1820 the quarries and works were sold for the small sum of 30,000 francs to Messrs. Dournay Brothers, who had already lent the establishment 60,000 francs.

In the hands of these skilful manufacturers the Alsatian asphalt trade soon rose to a great height, and as it continually grew in magnitude, Messrs. Dournay Brothers found themselves obliged in 1838 finally to form a share company with a capital of 1,200,000 francs. This event occurred when the Seyssel company, under Count de Sassenay, was at the acme of its reputation, especially in reference to foot pavements.

At this time the long-forgotten quarries of Val de Travers were again thought of—those quarries from which the whole branch of trade had in the first instance originated; and in this matter the intelligent Count de Sassenay again took the lead. He also transferred his undertakings at Seyssel to a large company of capitalists, and turned his attention to the scene of the labours of Eirinis. The reasons for this step he gives in express words, in the May of 1838, as follows:—"When the first samples from the quarry of Val de Travers were laid before me, I was obliged to conquer my conviction that they came from the best part of the rocks of Seyssel, so great is the similarity between them. But although I was struck by the richness of the material, I could not think of purchasing this second quarry without a careful examination of its stratification and the estimated quantity of substance there to be found. In so important an undertaking I resolved not to be guided by my own experience. I therefore associated M. Henri Fournel with myself in the matter, a gentleman well known for his conscientious hesitation, and, accompanied by this distinguished engineer, I have examined the whole district of Val de Travers. I found that the valley contained an asphaltic rock identical with that of Seyssel, its grain being somewhat finer, and the yield about two per cent. more bitumen, a quality of the highest importance in a mercantile sense, effecting a great saving in the application.

"This asphaltic limestone is found on both sides of the valley, and to a great distance in an uninterrupted series, reaching below the mountains which enclose the valley. In view of the enormous blocks accompanying the course of the Reuss, it is difficult to conceive how the supply can be exhausted."

A Frenchman named Brémond de St. Paul about this time had obtained a concession from King Frederick William III. of Prussia and the Government of the canton of Neufchatel, in Val de Travers, suspending all previous concessions, and securing to him the yield of the asphalt pits for thirty years, at an annual rental of 360 livres 10 sols. He was, however, forbidden to sell this concession; but when the Count de Sassenay determined upon the purchase of the pits, a sale was sanctioned, and a royalty of one-tenth of the nett returns fixed upon, or 10 centimes a hundredweight of the rough material. Under these conditions he transferred the concession to the Count de Sassenay, who founded a large company in Paris for the purpose, and obtained for himself the right of free import into France. Thus three great centres of asphalt industry were established, all in the hands of French companies, at Seyssel, Lobsan, and Val de Travers. It was, however, a long time, despite the good reputation in which asphalt now stood, ere pavements of this substance could be introduced into towns at any distance from the centre of manufacture. The public purse-strings were drawn tight when so many square metres of pavement had to be covered with this expensive material. Nor could natural asphalt be delivered, except at a high rate, on account of the distance of Germany and England from the place of production, and although the three companies tried to reduce the price by competition, the cost of transport still remained as a dead weight on the trade.

This not only directly affected the spread of the asphalt trade, but in other ways influenced it in a sinister manner. The price which real asphalt commanded was very tempting, and it was easy to produce imitations of a worthless kind with chalk, pitch, and common gas-tar; and all classes of workmen, even architects themselves, soon learnt to call by the name of asphalt anything which would fuse like pitch, an error which has perpetuated itself to the present day. Hence mastic factories everywhere arose, introducing a fictitious article under the name of asphalt; even masons who had succeeded in producing some kind of fused gas-tar did not hesitate to recommend such a base imitation for the laying of foot-pavements. This of course produced grave results in the veritable industry of asphalt. It can never be too often repeated that asphalt possessing its really good qualities can only be manufactured from the natural rock product.

It has been found impossible to imitate the close union of limestone and viscous mineral tar. When chalk or firm porous limestone was taken and boiled for a long time with pure, natural, viscous mineral tar, and then treated like natural asphalt, it was possible to obtain well cast cakes which smelt like those obtained from the asphalt pits. But the pavements laid down with this artificial substance evinced very different qualities in reference to resistance and durability. The union of mineral tar with limestone, which occurs naturally, was evidently the result of a thorough saturation of the limestone by petroleum, afterwards oxydized by the action of thousands of years. Thus these substances are intimately united in a manner that only chemical force can effect; hence it is that neither sunshine nor rain can divest natural asphalt of its bitumen or harden it, and that the veriest outside surface can alone suffer slight deterioration. The mastics prepared from natural mineral tar are also very adaptable for air-tight places, for isolating layers in the foundations of buildings, and for the covering of casemates and bridge arches; but these must not be exposed to the sun, must not be used for pavements, as they are liable to great waste by the action of the elements. Still, they are far better than the bad mastics so frequently recommended by interested and inexperienced persons, having common gas-tar as the chief ingredient. These generally fell to pieces in a very short time, even when they had been subjected to very little traffic, the oils of gas-tar being too volatile, the pitch too friable, causing the pavement to be too soft in summer and falling to pieces in the winter. The disrepute caused by the introduction of these bad imitations has had a sad effect upon the trade in real asphalt, and important works have thence often been carried on at a serious loss.

The extension of the railway system, and the discovery of new deposits, has, however, to a great extent, put an end to this state of things. Since railways have branched out over the whole of civilized Europe, it has been possible to deliver asphalt in the interior of Germany and at the coast, at far less cost, and the increase of knowledge on the part of engineers has forced the imitation article out of the market, at least in great public works.

In 1843 Mr. Henning opened a bed of asphalt at Limmer, near Hanover, in the heart of Germany. This stone is a limestone filled with shells, and completely saturated with viscous mineral tar belonging to the upper Jura formation, and is in quality and age quite similar to the asphalt of Seyssel and Val de Travers, both in chemical constitution and origin, so that there can be no distinction made between the French and German asphalts. In outward appearance, and when cut with a knife (under which circumstances it looks like chocolate), it is exactly like the stones from the Jura mountains. It is therefore prepared for pavement in a precisely similar way. It is broken and reduced to powder in a mill, melted up with some mineral tar, formed into cakes, which are sent to market, and are afterwards treated as are the French, Swiss, and other asphalts. In consequence of this discovery the name of Limmer was soon blazoned on footways beside those of Seyssel, &c.; entering into competition with the older pits with success, especially as the richer quality rendered the article cheaper. At the first London Exhibition the Limmer asphalt received preference above the other sorts, and the name of "German asphalt," which had formerly been a term of reproach affixed to the base imitations—Germany having no asphalt pits—at length became a designation of honour. The handsome and spacious footways of the city of Hanover bear testimony to the excellence of the material.

The frontier of the mountains towards the North German plains is especially marked by asphalt beds, and the mineral tar, which has, since time immemorial, bubbled to the surface in the

sandy plains north of Hanover, became a mainstay of the Limmer asphalt trade.

Asphalt was pushed out of the market gradually in some places by other material, especially, as in Berlin, by granite, by rifled clay flags, by clinkers of easily melted clay, and by sandstone flags.

Under these circumstances it has been necessary to find some application of asphalt in which it can be used without fear of competition. This use has been found; it consists in the asphalting of the roadways of the streets of great cities, an enterprise demanding an inexhaustible supply of the material, and evidently greatly fostered by the increased facility of transport afforded by the railways.

For a very long time it had been projected, and experiments had been tried in laying the carriage-ways of great cities with squares of asphalt, in order to familiarize the inhabitants with the convenience of an even surface. Experiments were first tried at various points in Paris, by fusing broken roadstones with asphalt, laying them on sand beds, and connecting the seams by a solution of hot asphalt.

These experiments did not succeed. The asphalt mastic was too brittle in the cold, and when the quickly revolving carriage-wheels came in contact with the corners of the asphalt flags, pieces were broken off. A fracture of this kind soon grew into a serious hole, and the result was very difficult to repair. In Lyons it was attempted to render the asphalt mastic so firm that it would resist the wear and tear of the wheels and the hoofs of the horses. This was tried with a layer of mastic 5 centimetres thick, with a dressing of $\frac{2}{3}$ of gravel, the foundation being of béton, one decimetre in thickness. More than 10,000 square metres of mastic roads have thus been laid in Lyons, and have admirably succeeded. In all other towns, in consequence of the great expense of material, it has only been sparingly applied, especially on bridges, at the intersection of streets, in the room of pavement at the entrance to theatres, hotels, and large private palaces, near hospitals and the halls of deliberative assemblies, where the traffic of the streets is a nuisance. In these places the surface has usually been slightly rifled, to prevent horses from slipping; and probably this was very proper, as the animals only remain a few seconds upon this surface, and therefore cannot accustom themselves to the difference existing between this surface and the ordinary roadways. In Lyons, however, this has not been done, the horses in that town having accommodated themselves to the new pavement without any difficulty in the principal streets.

At Vienna, the great Aspern Bridge has been laid in asphalt mastic of Austrian origin, from Seefeld, or Tyrolese and Dalmatian asphalt—there being two layers, the lower one being more elastic than the superincumbent layer. It has not been thought necessary to resort to rifling here, and yet the horses have not suffered by the passages of the bridge, and the material itself has not deteriorated.

For this purpose the Limmer asphalt has been found very applicable. The asphalt rock at Limmer is, in fact, somewhat fatter and softer than the Swiss and Savoy sorts—it is so fat that it is used to make up the somewhat thin asphalt of Vorwohle in ordinary footways, materially improving the surface. As without this qualification the Limmer asphalt is apt in summer weather to take slight impressions of carriage-wheels, it becomes very useful for carriage-ways. In this case a limestone pavement is laid as a foundation, this is covered with a layer of coarse asphalt some two inches thick, the mastic of which is boiled with 10 per cent. of *goudron*, the gravel added being of the size of a hazel nut, which is pressed close together after being laid down. Over this is a layer of asphalt, composed of 75 per cent. of mastic, 3 per cent. of *goudron*, and some 22 per cent. of common coarse sand, to the thickness of an inch. This carriage-way has come into use in many places on bridges, and, now that the factory is in the hands of an English company, it has met with approval in the streets of London. Similar blendes are to be found in the kingdom of Hanover in coach-houses and stables, and it is frequently laid in cavalry stalls for the front legs of the horses. The saving in straw, the easier cleaning out of the stalls, and the prevention of strong ammoniacal vapours, has also induced the adoption of asphalt for stables in France for the cavalry and artillery.

Despite of the economy in transport brought about by the railways, it remains very expensive to enter upon the asphalting of entire streets; and although every control has been exercised, there is always much interference with traffic in consequence of the constant repairs necessary by the inexperience of the work-people.

The City Paving Commissioners found it necessary to endeavour to discover some new and better application of asphalt; for the continually increasing traffic it was impossible to depend upon any old system of road-making.

The stones in a square block pavement were displaced, the corners and edges broken off, and the interstices widened. In the holes thus formed the street mud accumulated, and with the accumulation of filth the danger of deadly miasma increased. It is easy to learn this by a mere examination of the earth on the paving being removed, the layer next the surface being of a black sulpho-hydrogenated character. Hence it was necessary to use smaller, harder, and dearer paving stones, by which the noise was partly deadened and oscillation lessened, but the evil-smelling joints continued, and the wear and tear remained the same. The falling of horses in the streets has even been rendered more frequent by some expedients—as, for instance, in Paris, by the Belgian porphyry pavement. Still worse was the system of macadamization adopted in Paris, from the terror of the street barricades. This system produces a mud road during wet weather and a dust storm in dry weather, and, in addition, constant repairs were required.

Asphalt alone appeared to be the only means by which these evils could be avoided, and strangely enough, the idea of using the rude asphalt stone itself for road-paving was the last to suggest itself, although the whole nature and constitution of the material was so admirably adapted for the purpose.

The asphalt stone itself is so softened by the bitumen, that in boring it for blasting an ordinary carpenter's gimlet can be used, and the stone can be shaped and cut into crooked fragments with a pocket knife. Those quarries which are worked in open day, such as Pyrimont, Seyssel, Val de Travers, and Limmer, suffer from this softness in the summer time, as the hammer only flattens the stone instead of fracturing it; and even the explosion of a bore-hole in a very heated rock-wall is unavailing, unless the loading is of dynamite or nitroglycerine. Continued summer heat acts upon the rock in such a way that the piled up stacks of broken stone standing through the summer collapse upon themselves. Even in winter, when the quarrying is chiefly carried on for this very reason, the sound of the hammer crushing together the stone is dull, like that of a blow made on a block of gypsum. This property of the stone ought to have suggested the idea that it was admirably adapted for a flooring by mere pressure, and as it is impermeable to water, was equally adapted to an open air flooring, *i.e.* a roadway. Nay, more, not only these considerations, but the immediate practical experience acquired at the pits indicated this.

Even at the time when, after Eirinis had first introduced the mastic of the Val de Travers, the asphalt stone was only used for the distillation of medicinal oils in the laboratories, the roads between the pits and the latter presented a singular appearance. Little pieces, fallen from the carts which brought the broken stone down in winter, were to be seen strewn over the soil, these were crushed by the wheels of other carts or fell into a coarse meal in the summer heat, and were gradually so pressed together by the traffic, that a firm, close, and elastic surface was formed on which horses could travel with ease, and bring down their loads without any apparent waste of the road. The author visited the pits of Val de Travers in 1856, and observed these roads with admiration, without knowing that a utilization on a great scale was here foreshadowed, or thinking of the true method of paving the streets of great cities in this natural way.

But far away from the pits, about 1840, experiments of the kind had been made on this basis, under the auspices of Count de Sassenay. Western France was the scene of these intelligent labours, and De Coulaine is the name of the engineer who brought them forward in the department Maine et Loire, and afterwards described them in the "Annales des Ponts et Chaussées."

The first attempt made on this plan was between Bordeaux and Rouen, near the city of Saumur. A layer of ordinary macadam was put down, and over this about an inch and a-half of coarsely broken up asphalt stone. Any one acquainted with the nature of asphalt stone would at once declare this to be remarkably practical, and, in fact, furnish the key to the enigma. But experience, our best teacher, decided otherwise. The new roadway was very firm at first, the protruding stones of the under bed were soon crushed or found a natural place, and in the empty spaces between, the light, easily friable asphalt, united with the stony meal of the crushed granite. The excellence of the material was soon visible. The thin coating of asphalt gave under the wheels without breaking; it showed the traces of every wheeled carriage and every stroke of a horse's foot; but the next carriage and horses destroyed the traces as easily as might be done in the dung yard of a farmer. Neither winter nor summer, especially wet weather, seemed to have any influence upon this new roadway. In consequence of such satisfactory results, new experiments, of a similar kind, were tried with good effect, particularly on the roadways of the great bridge of Saumur and several roadways and bridges on the line between Angers and Tours, as also between Angers and Briare.

At first all these roads told well; in fact, at length it was found that the very softest parts of the roadway, of which the greatest fear had been entertained, proved the best and most durable. It was afterwards found that on the great bridge over the Loire, the two arches above which the new asphalt roadway lay, were completely protected against the permeation of rain water, while all the other seventeen arches were subject to percolation, although they had been laid with the greatest care in hydraulic mortar.

Soon, however, an error was perceptible in these roads from the necessity of constant repairs. It was not long before the actual cause of this was seen. While the granite dust of the comminuted stones lay between the masses of asphalt and broke its continuity, it admitted the organic dirt and water, and prevented any consolidation of the upper layer of asphalt, the continuity of which was its chief merit.

It then appeared that the union of a common macadamized road with a covering of asphalt gave an unsatisfactory result; that it was rather a necessity to form asphalt into a continuous covering in an unmixed form—in fact, to realize on a larger scale what had only been hitherto possible in the neighbourhood of the asphalt pits. This conclusion may be easily arrived at now the proper method has been ascertained, but it was long even in France before the material was used in the new way, the most distinguished engineers still considering the macadamization above described to be the best method.

The first attempt at another method, now universally adopted, had in the mean time quietly been made on short distances of the road between Serrières and Travers. This was done by the engineer A. Merian, of Basle, to whom the honour of the invention of new asphalt road-making is to be solely attributed. It was Merian who first brought the asphalt meal in a heated condition upon the roadway, and artificially compressed it, in order to produce a uniform, firm, and impenetrable surface from the very first, and prevent the intrusion of moisture and substances of a dusty and crumbling nature. His work succeeded well, and although the foundation was very indifferent, the portions of highway so treated have remained in order to the present time.

The French engineers who attentively investigated Merian's process, acquired it from him; and although they cannot deny to the Swiss engineer the merit of the discovery, it is through him that their nation has preserved the reputation of excelling all others in the application of asphalt. In the same year Darcy, Inspector-general of bridges and roads, published in the annals of this branch of technics a long and learned dissertation, in which he discussed all the systems of pavings in vogue in London and Paris, and finally arrived at the conclusion that the solution of the question lay in the application of asphalt in a cold state for great cities—according to the method at Saumur—and even experiments were tried on the boulevards at his instance; but as the same imperfections showed themselves that had previously been visible on the road between Bordeaux and Rouen, Darcy also soon admitted that it would be best to have recourse to heated asphalt, and De Coulaine, the inventor of macadamized asphalt, alone adhered to his invention.

The difference from the works formerly executed in hot mastic—which has remained in use in many places, and especially in Lyons—and is still delivered from the Limmer factories, in Hanover, for roadways—does not exist solely in the cold stone, giving a certain amount of resistance by the union of its pulverized atoms, but rather in the heated powder which is adapted for such union, and is actually bound together by the pressure immediately applied to it.

Instead of a fluid layer produced by the mastic, this compressed layer does away with all the possibility of fracture, without losing the qualities of perfect homogeneity and impenetrability to water. But in elasticity a compressed covering necessarily excels the more or less fluid state of the mastic pitch, notwithstanding its mixture of gravel. On these very sensible grounds, not to be confuted except by other facts, great reliance was placed, when, about six years after the first experiments of Merian, a similar trial was given to hot compressed asphalt in Paris. The locality of this decisive trial, from which the rapidly increasing application of this beautiful discovery had arisen, was the Rue Bergère, beside the Conservatoire de la Musique. The pavement had lain here for four years, when it was determined to apply it to the Place du Palais Royal, where there was considerable traffic, and from that place it has been laid down almost everywhere; so that it is superfluous to name the streets in which it exists. But not one of these pavements, subjected to the greatest traffic and consequent wear and tear, has required renewal since that time.

The processes of this newest development of asphalt industry are thus described by M. Léon Malo, one of the best authorities on the subject:—

"The rude asphalt just as it is brought from the quarry is broken into pieces of the size of ordinary road stones, and then caused to fall to pieces by heat. This is done in drums of sheet iron over a proper furnace. The whole apparatus is brought to the place where the works are to be executed, or as near as may be convenient, in order that the pulverized substance may lose as little of its heat as possible. The surface of the street is covered with a layer of béton to about the thickness of one decimetre, or more, according to the soil itself. In some places, especially upon macadamized surfaces, this layer of béton may be dispensed with, but in others, where the ground is very soft, it requires to be some fifteen centimetres thick. The béton being carefully laid, it is levelled off in the proper directions. The curve of the road must be very slight, and hardly more than enough to throw off the rain-water, so that horses may not afterwards slip.

"As soon as the required curvature is attained, the mass of asphalt brought to a crumbling condition by the heat is spread out and compressed, and a layer of four to five centimetres produced, according to the amount of traffic to be provided against. This compression is finally regulated by passing a roller of 2,500 to 3,000 kilogrammes over the surface. In two hours the roadway is ready for traffic."

Thus far M. Léon Malo. His statements apply chiefly to the Seyssel asphalt, as the other pits had not at the time applied themselves to this new branch of industry. At Seyssel, enormous commissions, which usually suck the lifeblood out of the best industrial undertakings, had brought down the value of the whole, and two competing companies had brought down prices still lower; nor was it until 1856 that they united under the style of *Compagnie Générale des Asphaltes*, and so restored their product to its old reputation, and made it possible to do justice to the new application. M. Léon Malo himself went to the quarries, and remained there for ten years as engineer of the company, in order to study the properties of the stone in all its bearings, but more particularly in reference to roadways.

The *Compagnie Générale des Asphaltes* of Paris, which, in 1869, laid down a portion of roadway at the International Exhibition of Altona with compressed asphalt, handed to the author, who was then president of the jury, a manuscript statement from which the following facts can be quoted.

The company is now the only possessor of the concession for Seyssel from 9th fructidor, year V., with a capital of three and a-half millions of francs. Its factories are entirely established at Pyrimont. The Geneva Railway has built a special station for the transport. The winning of the asphalt at Pyrimont is partially by quarrying and partially by galleries cut into the rocky sides of the river Rhone. The stone is blasted with gunpowder. Although in 1858 only 80,000 cwts. were obtained, in 1868 there had been already 520,000 cwts. sold, more than one hundred miners and other workmen being employed. In order to bring these enormous masses to the factories, it was necessary to give up the old ox-carts, and they are now carried down by their own weight on inclined planes. About 1,300 cwts. of mastic are prepared per day by some 150 workmen, and therefore about 400,000 cwts. per annum, 150,000 cwts. of this being applied in a pulverized condition for the compressed roadways.

As the preparation of asphalt roads has attained its greater development since 1868, it is most probable that this proportion has greatly increased since then. In 1852, 800 metres had been laid in Paris; by the year 1858, quite 8,000 metres; by 1866, again, some 100,000 metres had been completed; and, according to the manuscript in the author's hands, about 1869 quite 280,000 metres of compressed asphalt covered the streets of Paris, especially in those parts of the city lying between the Rue Rivoli and the principal localities from the Boulevard de la Madeleine and the Rue Poissonnière. Some of these streets, the scenes of the liveliest traffic, had suffered not the slightest deterioration. The traffic on the boulevards well rivals that of other cities, but still more important is the traffic in the Rue Neuve des Petits Champs and the Rue Richelieu, through which streets at certain seasons of the year 5,000 vehicles daily pass.

The processes of the company have been materially improved by experience since M. Léon Malo wrote. The pulverization of the asphalt is not now obtained by heat, but by mechanical appliances, and it is reduced to a uniform granulated powder. The stone is exported in the form of fine ground powder. The powder of asphalt stone stratifies itself very firmly, aided by the oscillation of the railway waggons; hence, when it is not reloaded, there is little waste, which is again a great economy. The asphalt powder is heated to from 100° to 120° Celsius, in cylinders turning upon their axes like coffee roasters. This heating is effected very rapidly, in order that the powder may not dry, in other words, that a portion of the bitumen may not be lost. The heated powder is brought in wheelbarrows to the place where it is to be employed. It is necessary that the asphalt should find a firm foundation

prepared for it, for where the ground sinks the asphalt covering follows. When this foundation has been found to be of the necessary firmness, the surface is further secured by a layer of béton or concrete of varying thickness. As before stated, a béton layer is unnecessary on a well macadamized roadway. Here the surface alone is levelled to obtain an equal thickness on the part of the asphalt, and prevent a waste of material.

But the firmness of the ground is not sufficient ; care must be taken to avoid damp. At the moment it is used the water on the surface is evaporated by the heat of the powder, and the steam thus produced hinders the work, and, indeed, will prevent the amalgamation of the particles of asphalt powder.

Both a sure eye and a firm hand are required of the workman in spreading the asphalt, and very close attention and care can alone supply the place of experience and use. If the foundation be carefully levelled, it is sufficient to spread the powder regularly, and ascertain by measurement that the covering is of the same thickness throughout. This thickness must be some two-fifths more than the intended thickness of the compressed pavement, and either a rammer or a roller is used according to the importance of the work ; but before these appliances are used, the points of juncture, *i.e.* the places where the asphalt touches other substances, must be perfectly covered. Here a long thin rammer is used, called *foulon* by the French. This done, supposing the work to be of small extent, the ordinary rammers are next used. The pressure is gradually increased, beginning with very soft blows, and increasing their violence until the full compression is attained. If strong blows were used in the first instance it would displace the surface, and so render the surface uneven and ineffective. It is desirable that a like degree of strength should be exerted over the whole surface, or tears would be visible in parts. The last strokes of the rammer should be short and strong, in order to confirm the material at once.

If a large surface has to be covered, and the powder can be brought in sufficient quantities, a small roller is used for compressing it, containing a little basket of burning charcoal to prevent the powder from adhering to the surface of the roller. This roller is run across the road following the progress of the work, and gaining some 8 to 10 centimetres each time.

The next process is to drive light carriages with narrow felloes over the surface. This is a very useful procedure, but only of permanent advantage when judiciously done. Several carriage-wheels of similar diameter revolving on the same axle form the best machine for the purpose, following the heated roller as soon as possible. When this compression is completed, a hot searing iron is usually passed over the whole surface to give a finished appearance to the work ; compression, however, is not aided by this proceeding.

Should any portion of the asphalt road turn out faulty, either by accident or some peculiarity in the material, the following course is adopted.

All that part of the surface in which faults are shown is broken up and laid aside, care being taken that the edges are fresh, clean, and free from all extraneous matter or any moisture. This is done with a chisel and hammer, so that the perfect portions shall not be displaced, shaken, or cut through. This hole in the roadway being ready, it is necessary to see that the foundation is quite dry, and should it not be so it is carefully dried ; the powder is then carefully spread over it, and the original process followed. It is necessary that the edges should be more strongly rammed down, to confirm the binding of the old and new edges. These very simple methods are sufficient to insure a perfectly well made roadway of admirable equality and durability. One of the best examples of this method is to be found on the boulevard by the Senne at Brussels.

Although the Compagnie Générale des Asphaltes has thus broken a way for itself for city road-making, it would seem that they will have to cede this rank to the Val de Travers Company in all industrial enterprises, because the stone of the Val de Travers appears to be superior to the Seyssel stone in possessing a greater degree of bitumen, and also by a greater viscidity, owing to its degree of oxydation. The average amount of bitumen of the stone-meal of Val de Travers is 11 to 12 per cent., while that of Seyssel is only about 6 to 8 per cent., being, therefore, much dryer in constitution.

The bituminous limestone of Lobsan as a freshwater lime does not seem to possess enough interior hardness to form with the bitumen a resisting mass without other ingredients ; and the asphalt stone of Limmer, near Hanover, or that of Vorwohle, in Brunswick, is not adapted for this use, the former being too fat, and the latter too lean, nor can the amount of viscidity be obtained without melting. The factory manager, working upon English account, showed the author several pieces of roadway laid down upon the establishment, formed severally of compressed Limmer asphalt, Limmer asphalt combined with Vorwohle asphalt, also compressed, and of cast mastic, similar to that recently used in several London streets, and of these the cast mastic alone was of unquestionable quality. Under these circumstances, it is not strange that attention should rather be drawn to the Val de Travers, whence the Greek Eirinis gave the first impetus to the whole modern asphalt industry, and where Merian, the native of Basle, introduced the method of constructing roadways from compressed asphalt.

A few years since the old concession with its tithe expired, and then arose a competitive battle on the subject. According to the very unverifiable newspaper reports of the day, the gross proceeds amounted to 300,000 cwts., and for twenty hundredweights a fine of 1 franc 25 centimes was paid. The Government of Neufchatel demanded five francs for the future, and as the former concessionist would not pay this, the matter was put up to public auction. The highest bidding, however, now reached 19 francs 75 centimes, and the former concessionist had even offered as much as 19 francs 70 centimes, so that at the present about one franc per hundredweight has to be paid to the Government. From this it may easily be judged what importance this branch of industry had acquired.

On the 15th December, 1870, the Government of Neufchatel granted a concession to an English company, the Neufchatel Bituminous Rock Company, which, by purchase and treaty, entered upon the rights and obligations of the outgoing Val de Travers Company, and took possession of their factories. This company seems to have in view the paving of municipal towns by compressed asphalt, inasmuch as they ceded the material and method of laying down somewhat in the sense of a monopoly to individual paving companies which have been founded for various countries. Such a company exists for the United Kingdom with a minimum consumption of at least 200,000, and a maximum of 2,000,000 cwts. ; a second for the United States of America, with a minimum consumption of at least 40,000 and a maximum of 2,000,000 cwts. ; a third for South America, with a minimum of 40,000 and a maximum of 600,000 cwts. ; another for Austria, and one for Hungary and Roumania, each with the same limits of 40,000 to 600,000 cwts. Similar contracts have been entered into for Russia, Italy, Holland, Belgium, and Germany.

K. R. H. M.

(To be continued.)

Chemistry applied to the Arts, Metallurgy, Chemical Manufactures, and Allied Subjects.

ABSTRACTS FROM FOREIGN PERIODICALS, TRANSACTIONS OF CHEMICAL SOCIETIES, &c.

§ 1. *Acids, Alkalies, and Salts.*

PRODUCTION of Acrylic Acid.—CASPARY and TOLLENS treat bibromopropionic acid (obtained by oxidation of bibromopropylic alcohol) with zinc ; the bromine is thus removed as zinc bromide, and acrylic acid results. *Annalen der Chem. und Pharm.* 167, 240.

New Alkaloid.—H. GAL finds that when iodide of allyl is brought into contact with potassio-nitroethane, and the resulting body treated with zinc and hydrochloric acid, a volatile substance is produced possessing the composition and odour of piperidine, but differing from that substance in several respects. *Bull. Soc. Chim. Paris, xx.* 13.

Monochromatic Light in Alkalimetry.—L. D'HENRY uses the light of a Bunsen lamp, in which a platinum wire with a bead of common salt at the end is placed, to detect the exact point of neutrality whilst making alkalimetric assays when daylight is not obtainable. By ordinary candle light it is difficult to distinguish the difference between the blue, purple, and red tints of litmus ; but by the sodium light a red liquor (acid) appears colourless, whilst an alkaline one (blue) seems black and opaque.

This method can also be used for strong syrups, which are often deeply coloured. *Comptes Rendus, lxxvi.* 222.

Transformation of Alkaline Sulphates into Carbonates in the wet way.—PONGOWSKI has patented a process depending on the conversion of a mixture of carbonate of lime and sulphate of an alkali into bicarbonate of the alkali and sulphate of lime on passing carbonic acid through the mixture suspended in water. After eight hours the decomposition

is complete, when the liquor is allowed to settle, and the clear part siphoned off. *Bull. Soc. Chim. Paris, xix.* 477.

Manufacture of Sulphate of Ammonia.—L'HOTE proposes to treat albuminous and other nitrogenous refuse matters with a ten per cent. solution of caustic soda, to add quick lime to the viscid liquor that results, and to distil the whole at as low a temperature as is practicable, receiving the ammoniacal vapours disengaged in sulphuric acid. Toward the end of the operation the heat is raised to redness; the residue in the retort contains carbonate of soda, which can be causticized and used over again. *Comptes Rendus, lxxvii.* 1085.

MENE remarks that this process has been previously patented by Martin and Mène, but is not worked practically on account of various objections and difficulties. *Comptes Rendus, lxxvii.* 1307.

Manufacture of Potassium Iodide from the Mother-Liquors of Kelp.—The process described by E. SONSTADT consists in converting the alkaline iodides contained in the mother-liquors from kelp into iodates, first precipitating all sulphuric acid from the liquors by barium solution, by which process all the silica is also thrown down, together with other impurities. The filtered mother-liquor is then boiled down and fused to destroy organic matter. The fused mass dissolved in water is rendered alkaline by addition of caustic or carbonated alkali, in the proportion of five equivalents of caustic alkali or ten of carbonate for each equivalent of iodide contained, for all but the last of the under-mentioned processes.

The iodic acid is precipitated by a soluble barium salt, and the precipitate heated with solution of potassium sulphate, which gives potassium iodate in solution. This solution is evaporated to dryness, the residue fused, and the fused iodide of potassium thus obtained is dissolved and crystallized.

For the conversion of iodide into iodate the following processes are employed:—

1. Chlorine is passed through the liquid till all the iodide is transformed into iodate, but not longer.

2. Solution of permanganate is added until a slight permanent red coloration is produced. The liquid is separated from the manganese oxide precipitate; the latter may be furnaced with soda and nitre to reproduce permanganate.

3. An electric current is passed through the dilute solution, the electricity being most economically obtained from electro-magnetic machines worked by water power.

4. The purified mother-liquor is evaporated to dryness, with addition of one equivalent of an alkaline chlorate for each one of iodide present. The mixture is then carefully heated below redness until the iodide is converted into iodate.

After separating the iodic acid, the bromide remaining in the mother-liquor may be converted into bromate by either of the above-mentioned processes, 1 or 4; potassium bromide may be obtained by the same methods as are used for the preparation of potassium iodide.

Processes 2 and 3 are not applicable to the formation of bromate. *Polyt. Centralbl.* 1872, 1432.

Phosphide of Iron.—R. SCHENCK prepares this substance by the action of caustic potash and phosphorus on ferrous sulphate. It is a black powder, of composition expressed by the formula $Fe_3 P_2$, soluble in dilute acids on long boiling, and taking fire when dry at temperatures below 100°. *Paper read before the Chemical Society, June 5th,* 1873.

§ 2. *Metallurgy.*

Puddling Furnace.—MACKINTYRE patents the use of a special rotary furnace which is not circular but has an outline representing a curve with two points of contrary flexure. The ball is thus worked by the rotation of the furnace, being raised up and let fall twice at each revolution. *Bulletin Soc. Chim. Paris, xx.* 48.

Alloy of Cast-iron and Copper.—COINDET patents the use of an alloy produced by melting together 100 kilogs. of cast-iron, 1 kil. suboxide of copper, 1·5 kil. red copper, and 3 kils. black flux. The product can be hardened and tempered like steel. *Bulletin Soc. Chim. Paris, xx.* 48.

Desulphurization of Pyrites.—LAMY reports that M. Perret has invented a special kind of furnace for the total desulphurization of pyrites; it consists essentially of a pyrites kiln with a series of earthenware shelves above, on which the dust is placed; the burning of the pyrites keeps these hot, and after from 24 to 36 hours all the sulphur is eliminated. A second roasting may be performed on a series of shelves where every other shelf contains raw pyrites to keep up the heat, the alternate one containing the partially roasted material; only two to three thousandths of sulphur are left by this treatment. Excess of air must be used to bring about more rapid oxidation; the furnace must be so arranged that the products of the second roasting can be withdrawn without mixture with the half-burnt material. *Bull. Soc. d'Encouragement, April,* 1873.

Nickelization of Metals and Alloys.—MARTIN and DELAMOTTE employ an organic salt of nickel in preference to a mineral one; a convenient bath is made as follows:

1·25 kilogs. citric acid,
0·50 „ hydrochloride or sulphate of ammonia,
0·50 „ nitrate of ammonia,
15·0 litres of water,

are heated to 80° and the solution saturated with recently precipitated oxide or carbonate of nickel; 2 litres aqueous ammonia liquor are then added and the whole diluted to 25 litres; after cooling, 0·5 kilogs. of carbonate of ammonia are added; the liquor thus produced is of a black-blue tint and has the specific gravity 11°; it allows a thick metallic coating of nickel to be obtained with a suitable battery, the most advantageous temperature being near 50°. Addition of caustic soda or potash rather facilitates the deposition than otherwise. *Bulletin Soc. Chim. Paris, xx.* 44.

New Mode of Lead Assay.—MASCAZZINI heats the ore to be valued with twice its weight of ammonia sulphate; the metals present are thereby converted into sulphates. By boiling with a mixture of diluted hydrochloric and sulphuric acids, all iron, copper, &c. is dissolved, whilst lead sulphate and silver chloride are left. These are washed, dried, and reduced with zinc and hydrochloric acid; the resulting metallic mass is fused in a crucible along with a flux of thirteen parts potassium carbonate, ten sodium carbonate, five of borax, and five of starch. Ceruse, minium, ores rich in silver, gold, antimony, tin, copper, &c. and analogous substances, may be thus assayed. If there is not enough lead present for cupellation in the case of silver ores, more may be added. *Dingler's Polytech. Journal, ccvii.* 46.

Rapid Desilverization of Lead.—ROSWAG and DE PAUVILLE patent a process consisting of treatment with zinc, eliquation of lead, amalgamation of the zinc scoriæ left, squeezing through chamois leather, and eliquation at a low temperature of the solid mass left. The lead amalgam thus obtained contains nearly all the silver, which is separated by distillation and cupellation; the zinc scoriæ thus left are again amalgamated to extract the last traces of silver, the adhering mercury distilled off, and the residue melted with tar and used over again. *Bulletin Soc. Chem. Paris, xx.* 46.

Explosive Antimony.—When a copper negative pole is employed to electrolyze a solution of antimony chloride, the positive pole being platinum, a film of antimony is thrown down on the copper; when rubbed in a mortar, or struck with a hammer, this deposited metal detonates sharply, owing probably to its passing from the amorphous to the crystalline state. *Les Mondes, xxxi.* 471.

Gold Platinization of Glass.—DODE patents the use of the following process. The mirrors being brought to a proper state of surface by operations entitled *dressing*, *softening*, *soaping*, and *polishing*, are painted over with the following mixture; the glass is then heated to dull redness, a second coat being applied if necessary.

500 grammes platinum are dissolved in aqua regia, 5 kilogs. of water added, and two of salammoniac; the precipitated ammonium platinochloride is washed, dried, and treated with 50 grammes hydrochloric acid and 50 of nitric acid; 50 of water are added, and the whole evaporated to dryness; the whole is pulverized and mixed well with 2,000 grammes essence of lavender, 100 essence of turpentine, 25 turpentine balsam of sulphur. To the resulting liquid is added the ethereal solution of chloride of gold, made by dissolving 50 grammes of gold in aqua regia; also the following mixture—50 grammes litharge, 50 borate of lead, and 100 essence of lavender previously ground up and mixed together. *Bull. Soc. Chem. Paris, xix.* 572.

§ 3. *Dyeing, Calico Printing, Bleaching, and allied subjects.*

Aniline Black.—BRANDT considers that there are two different products contained in aniline black. One is formed by chlorinous substitution in the aniline used; this is very stable, resisting almost all chemical agents, but it is not as fine a black as the mixture of this first product and the second, produced by the oxidation of an aniline salt. The first is of a brown-black hue, the second of a deep violet blue, becoming black in larger

quantity; the two together, in proper proportions, form a true, good black. The second compound is altered by even small quantities of acids, but resists soap. The one or the other of these substances predominates according to the mode of operation, the first being produced in presence of excess of aniline, the second when the acid is in excess. The production of a good black is favoured by the use of chlorate of aniline instead of chlorate of potassium. *Moniteur Quesneville*, 1873, 243.

Aniline Black.—LAUTH dyes cotton, silk, or wool, by impregnating the fibre with peroxide of manganese, and then passing through a solution of an aniline salt. To mordant the goods with manganese, alkaline manganates or permanganates can be used; but these being very expensive, the old process for dyeing manganese bronze can be adopted, viz., soaking the fibres in acetate, sulphate, or chloride of manganese, passing through caustic soda, and oxidizing the manganese oxide thus precipitated in the fibre by means of chloride of lime. For an intense black, chloride of manganese at 40° B. is used; the goods are worked in this bath for an hour, wrung out, and passed without rinsing into a boiling soda lye at 12° B., in which some lime is suspended. The cotton is then washed in much water, and passed into lukewarm chloride of lime, the proportion of this latter being regulated so as not to be in excess. It is best to add the chloride of lime to the bath in small quantities at a time until the manganese bronze tint is sufficiently deep.

Although this method seems practical enough, yet it is found actually to require precautions which dyers are not usually in the habit of taking, and to be a somewhat more delicate operation than appears at first sight. The treatment with soda is unpleasant to the workman, and roughens the cotton, whilst excess of oxidizing agent (chloride of lime) injures the fibre. It has been found, therefore, that the process has been too difficult for ordinary use, and it has therefore been abandoned for dyeing purposes; it gives, however, good results when applied to calico printing. The fixation of peroxide of manganese on the fibre may be accomplished by exposing the goods mordanted with manganese liquor to an atmosphere impregnated with ammonia; the protoxide of manganese thrown down speedily peroxidizes spontaneously under these conditions.

The mordanted goods are well washed, to eliminate uncombined matters, and are then steeped in a cold acid solution of aniline; the colour appears almost instantaneously, the reaction taking place as soon as the bronze comes in contact with the aniline salt, the latter being oxidized and taking the place of the manganese compound. The operation is finished in a few minutes, but the goods may be left in the baths for an hour or more without damage. The proportions requisite vary with the shade of black required, excess of acid being always used; thus, to 10—20 grammes of aniline per litre, 60 grammes of sulphuric acid must be used; to 50 of aniline 150 of acid; greater excess than this should not be employed, otherwise the mordant may be attacked. Hydrochloric, arsenic, or other mineral acids can be used instead of sulphuric acid. After passing through the dye bath the cotton is well washed, and passed through a bath of boiling soap or soda to remove the last traces of acid. The finished goods may have the black tint deepened and brightened by a further treatment with bichromate of potash (1 gramme to the litre), salts of copper, mercury, or chromium; or, best, a mixture of chlorate of potash, a salt of copper, and chloride of ammonium (1 gramme each per litre); this treatment is applied after the washing, subsequent to the dyeing process, and is kept up for half an hour at a boiling heat. Fine solid blacks are thus obtained, the process being speedy and not injurious to the fibre; the black stains off a little when rubbed.

In calico printing this process is suitable for black grounds; black grounds with discharge effects in all colours; greys (produced by weaker mordants); black and grey shades and patterns capable of resisting the various operations above mentioned (iron, chrome, and indigo); black and indigo; blue grounds with white discharge and black patterns, &c.

Pure aniline employed thus gives a fine intense black; toluidine, a blue-grey; methyl-aniline, a violet-black; naphthylamine a violet-brown; the differences in shade are so great that cloth thus mordanted may be used to determine the comparative values of various samples of commercial aniline. *Bulletin de la Soc. Chim. Paris, xix.* 437.

Dyeing Cotton with Aniline Black.—VINAUT employs the following process, which requires great attention lest the black should become mottled. The cotton is well boiled and then dipped in copper sulphate dissolved in water acidulated with a little hydrochloric acid (200 grammes of sulphate per kilogramme of material). Then it is dipped in a bath at 50° containing 50 grammes of sulph-hydrate of sodium per litre, and rinsed; then in a bath of 10 litres water, 180 grammes chlorate of potassium and 170 grammes sal-ammoniac dissolved by heat, 480 grammes of aniline hydrochlorate being added. Finally the goods are hung in a warm chamber at 24° for forty-eight hours, and are then passed through a bath at 30° containing 1 gramme of potassium dichromate per litre, rinsed, and dried.

A reddish tint may be removed by passing through a bath of chloride of lime at 6° 1 litre, cold water 100 litres. *Moniteur de la Teinture, i.* 67.

Pearl Grey from Aniline Violet.—Faint shades of pearl grey are readily communicated by weak baths of aniline violet; the finer the violet the purer the grey. Extremely fine qualities of dye are unnecessary. Cottons may be dyed without mordant, a slightly soapy bath free from acid being used, and a very small quantity of acetic or tartaric acid being added at the end. Pure woollens require only a plain lukewarm water bath without any acid. *Moniteur de la Teinture, March 20th*, 1873.

Printing Aniline Colours.—An aqueous solution of glue, containing 50 grammes of glue per litre, is mixed with a few drops of potash bichromate; to this is added the aniline colour which it is desired to employ, and so much starch or dextrin as required for thickening.

After printing with this colour, the goods are exposed to daylight, which fixes the colours, in consequence of making the mixture of glue and bichromate insoluble.

Instead of glue a solution of caseine in ammonia may be employed. *Polytech. Centralblatt*, 1872, 1501.

Dyeing Cotton with Alkali-blue.—A. SCHLUMBERGER, manufacturer of aniline colours at Brussels, proceeds in dyeing with alkali or Nicholson blue in the following manner: The goods are passed through a cold solution of potash permanganate, and after they have acquired a light brown colour (through the formation of manganic peroxide), taken out and soaked for an hour in a tin-salt bath of 4° B. concentration. In this second solution the tin is deposited in the tissue, whilst the manganese of the peroxide passes into the bath. This preparatory treatment is followed by the dyeing proper. For every 10 kilogs. of cotton 30 to 50 grammes of colouring matter are employed. This quantity is divided into two portions, one of which is dissolved and poured into a hot solution of half a kilog. of soda and the same amount of alum. Through this bath the goods are passed six times. The bath is then re-heated to its former temperature, the reserved half of alkali-blue and 1 to $1\frac{1}{2}$ kilogs. of alum added to it, and the goods passed through it six times. The light blue which the cotton has acquired in the first bath is now transformed into the finest dark blue which as yet has been produced in the dyeing of cotton. It is to be observed that the bath must not be used immediately after preparation; a fresh bath requires twice as much colouring matter as an old one. Semi-cotton goods can just as well be dyed after this method; it is only necessary to add to the bath soluble glass or borax. *Polytech. Centralblatt*, 1872, 1434.

Anthracene Derivatives.—E. KOPP states that two different dye stuffs are met with in commerce, viz.: "alizarin" (containing alizarin in a more or less pure state, and giving rose and violet shades); "artificial purpurin" (containing alizarin and its purpurin, and yielding red and puce tints); these are met with as pastes, containing 10 to 15 per cent. of dry colouring matter, the latter being the usual standard. At the same price, more colouring matter is contained in madder, garancine, and "fleur de garance," than in these pastes; but the much less cost for soaping, clearing, &c. the goods dyed with the artificial colour renders these preferable for many purposes. They are used in just the same way as madder colours, calcareous water being avoided, as lime lakes are more readily formed by them than with madder colours, which contain pectic acid and other vegetable substances which take up the lime.

Neither madder, garancine, nor their extracts, can be used for steam colours, even when well purified with alcohol, wood spirit, acetic acid, &c., as brown and dusky tints are apt to be communicated; purified alizarin, or purpurin, however, answers well. Mordants with *two* bases (*e.g.* lime and alumina) are more stable, and stand soaping better than those where only a single base (lime, tin oxide, alumina, &c.) is present. The presence of fatty matters also augments the brilliancy of the lake thus formed, and hence the goods must not be placed immediately in a boiling soap bath, but must be first placed in one not too highly heated. Acetic acid, having no injurious action on vegetable textile matters, is to be recommended as a solvent.

The following receipts (originally given by Grothe, "Muster-

zeitung," 1871, Nos. 21, 30, and 46) are given, together with others :—

THICKENINGS.

	For Red No. 1.	For Red No. 2.	For Violet.
Wheatstarch	6 kilogs.	6 kilogs.	5 kilogs.
Water	20 litres.	17 litres.	18 litres.
Acetic acid at 6° B. .	4 „	17 „	3 „
Olive oil	1,500 grammes.	1,500 grammes.	1,000 grammes.
Mucilage of gum tragacanth (60 grammes per litre).	10 litres.	—	9 litres.

ALUMINA MORDANTS.

Nitrate of Alumina.		Acetate Alumina.	
Nitrate of lead . .	10 kilogs.	Acetic acid at 8° B.	6 litres.
Alum	10 „	Alum	36 kilogs.
Boiling water. . .	20 litres.	Soda crystals . .	31 „

For the nitrate the materials are simply added together, mixed well, allowed to stand, and the clear liquor syphoned off from the precipitated sulphate of lead. For the acetate, the alum is dissolved in 400 litres of water and the soda in 400 litres of water. The solutions are mixed, whereby a basic sulphate of alumina is thrown down; this is dissolved in the acetic acid after having been well washed by decantation (eight times), strained in a filter, and pressed.

For 100 parts of alizarin paste containing 15 per cent. of dry colouring matter, thirty parts of alumina acetate liquor at 12° B. suffices; if the paste contains 10 per cent., 20 parts of this liquor are required.

ACETATE OF CALCIUM MORDANT.—Solution of calcium acetate at 16° B., contains 25 per cent. of dry salt; 100 parts of alizarin paste at 15 per cent. require fifteen parts of this mordant; if at 10 per cent., ten parts.

STEAM COLOURS.

(1). *For Red Bottoms.*

Alizarin paste at 15 per cent. .	800 grammes.
Or „ „ at 10 per cent. .	1,200 „
Acetic acid at 6°	1 litre.
Water	2 „
Olive oil	200 grammes.
Acetate lime at 10° B. . . .	200 „
Wheat starch	500 „
Acetate of alumina . . .	200 „

The last ingredient mixed in after boiling and cooling.

(2). *For "Article Mille Fleurs."*

Alizarin paste at 15 per cent. .	2,600 grammes.
Or „ „ at 10 per cent. .	4,000 „
Thickening for reds . . .	10 litres.
Nitrate of alumina at 15° B. .	300 grammes.
Acetate of „ at 12° B. .	600 „
Acetate of lime at 16° B. . .	400 „

(3). *For Deep Reds.*

Alizarin paste at 15 per cent. .	3,300 grammes.
Or „ „ at 10 per cent. .	5,000 „
Thickening for reds . . .	10 litres.
Nitrate of alumina at 15° B. .	400 grammes.
Acetate „ at 12° B. .	600 „
Acetate of lime at 16° B. . .	500 „

(4). *For Reds without Olive Oil.*

Alizarin paste at 15 per cent. .	2,800 grammes.
Or „ „ at 10 per cent. .	4,200 „
Acetic acid at 8° B. . . .	4,800 „
Starch	1,800 „
Water	2,400 „
Acetate of lime at 16° B. . .	487 „
Nitrate of alumina at 15° B. .	1,000 „
Hyposulphite of calcium at 9° B. .	1,500 „

The last three ingredients mixed in after boiling and cooling.

(5.) *For Violet.*

Alizarin paste at 15 per cent. .	900 grammes.
Or „ „ at 10 per cent. .	1,400 „
Acetate of iron at 12° B. . .	200 „
Acetate of lime at 16° B. . .	370 „
Thickening for violets . . .	10 litres.

After steaming for one to two hours with steam at half atmosphere pressure, and hanging for 24 to 36 hours, the goods are passed for two hours into the following bath, at 50°—62° :—

Water	1,000 litres.
Chalk	20 kilogs.
Arseniate of soda. .	5 „

and are then soaped at 62°—75° with 1,500 grammes of soap for every ten pieces of fifty metres.

(6.) *For Puce.*

Alizarin paste at 15 per cent. .	6,000 grammes.
Or „ „ at 10 per cent. .	9,000 „
Nitrate of alumina at 18° B. .	900 „
Acetate of alumina at 13° B. .	400 „
Acetate of lime at 18° B. . .	500 „
Red prussiate of potash previously dissolved in a little water . .	400 „
Thickening	10 litres.
If a yellowish puce is required, add extract of quercitron at 20° B. .	30 grammes.

Dry commercial purpurin has 50–60 times the colouring power of an equal weight of madder; it gives limpid baths, and dyes without requiring an elevated temperature. On calicoes, red, rose, and black mordants dye quickly. A slight soaping at 45°—50° brings out the white and revives the colours. Violet mordants act equally quickly, but give greyish tints; it is well suited to articles of white bottom, such as handkerchiefs, one or two grammes sufficing to dye a square metre of even the most intensely coloured design; it also resists the action of air and light, but not so well that of boiling soap. The purpurin is best dissolved by means of 20 per cent. of its weight of carbonate of soda, the salt and dye stuff being rubbed up together, and warm rain water added to the resulting mass, which dissolves wholly, forming a magnificent red liquor; this is filtered, cooled, and thickened to the right consistency; the goods are then printed, steamed, and washed in cold water.

For woollens, purpurin is used with madder mordants, *e.g.* alum and cream of tartar, or tin and tartar. The best tin liquor is the following :—

Nitric acid	300 grammes.
Water	100 „
Salammoniac . . .	50 „
Tin	50 „

the tin being added in small quantities at a time, and the whole cooled. The liquor must stand some days and be filtered before use. For mordanting, the goods enter the bath at 30°, and in half an hour the temperature should have risen to 70°; they are then rinsed and dyed with the purpurin bath at 30°, the temperature rising to boiling in half an hour.

Alum and cream of tartar mordants thus give a bright crimson red; tin and tartar give a scarlet red nearly as fine as cochineal; from 2 to 4 grammes per square metre suffice for merinoes and muslin-de-laines. For bright orange reds, extract of fustic or Cuba wood is added to the mordant liquor.

Silk may be tinted with purpurin after mordanting with acetate of alumina or with basic sulphate prepared by saturating alum with gelatinous alumina; in the former case a little chalk should be added; the goods are then dried and slightly gummed with gum senegal, or tragacanth, 2 to 5 grammes to the litre; the printing colour is then made as follows :—

Purpurin	32 grammes.
Soda crystals . . .	12 „
Pale roasted starch . .	200 „
Water	1 litre.

After steaming the goods are soaped at 45°—50°; a little tannin may be added to the colour, 0·5 to 1 gramme dissolved in water containing 1 gramme of soda crystals.

Any salt of alkaline re-action will dissolve purpurin; borax answers well, but a larger quantity is requisite than is necessary of carbonate of soda; bicarbonates and carbonates of soda, potash, or ammonia answer, but silicate of soda gives a gelatinous precipitate on standing for a few moments.

Purpurin lakes may be formed in three ways: (1) Boiling alum solution dissolves purpurin; chalk precipitates the lake from the partially cooled liquor. (2) Purpurin is dissolved in carbonate of soda solution, and alum liquor added. (3) Gelatinous alumina or subsulphate is precipitated from alum by addition of cold carbonate of soda solution, and is washed two or three times by decantation; this is then disseminated through water and a solution of purpurin in dilute ammonia water or soda carbonate solution is added; no more of the alkaline solution must be used than is required to dissolve the purpurin. According to the quantity of purpurin the lake is of a light red, rose, bright red, or deep red. *Moniteur Quesneville*, 1873, 14.

Anthracene Blue.—F. SPRINGMUEHL obtained this colouring matter as a bye-product of the manufacture of alizarin. It is soluble in water, and dyes silk, wool, and cotton of a splendid and permanent blue. The colour has, however, yet only been prepared in small quantity. *Polyt. Centralbl.* 1872, 1434.

Isopurpurin.—This isomer of purpurin has been obtained by Auerbach from a colouring matter which occurs in commerce under the name of "artificial purpurin." The isopurpurin dissolves easily in boiling water and in alcohol, and dyes goods as fine red as purpurin itself. It resists soap tolerably well, but not as well as alizarin. *Polyt. Centralbl.* 1872, 1502.

Ink for Calico Printing, &c.—The following mixture forms a good ink :—

Venice turpentine . . .	9 parts.
Soft potash soap . . .	10 „
Oleine	4 „
Calcined soot	6 „
Bleu de Paris	1 „
Oxalic acid	0·5 „
Water	1 „

The turpentine is warmed with purified oleine and incorporated on a stone slab with the potash soap in small quantities at a time. When well mixed, sifted lamp black is added, and subsequently the bleu de Paris in fine powder, and the oxalic acid and water, continual stirring being kept up, the material being previously slightly warmed.

Indigo carmine may be used instead of bleu de Paris and oxalic acid. *Moniteur de la Teinture, March 20th*, 1873.

Violet "Exton" for Wool.—A dye bearing this designation is manufactured by a firm in Bâle ; its use is characterized by the circumstance that the dyeing and washing take place simultaneously. *Polyt. Centralbl.* 1872, 1372, *from Reimann's Färber-Zeitung.*

"Siderin"-Yellow.—B. KLETZINSKY prepares a basic chromate of iron by continued boiling of 433 parts by weight of crystallized ferric chloride with 1,473 parts of permanganate of potash. The substance forms a fine yellow, being especially well adapted for use with soluble glass, with which it forms a hard cement. Mixed with ultramarine it produces a beautiful green colour. *Polyt. Centralbl.* 1872, 1432.

§ 4. *Food and Sanitary Matter.*

Apparatus for Heating Wines.—TERREL DES CHENES employs a heating arrangement consisting of a water bath heated to the required temperature through which passes a set of forty tin tubes 4 millimetres in diameter ; these are all in connection with the supply-pipe, so that the heating up of the wine is effected very rapidly in consequence of the large surface. In the same way, the heated wine is again refrigerated in another vessel, so as to reduce its temperature before entering the receiving casks. 15 hectolitres per hour can be thus heated and matured at a cost of 75 centimes, the wine never coming in contact with the external air throughout the whole operation. *Moniteur Quesneville, xxx.* 451.

Turning bitter of Red Wines.—NEUBAUER finds that the tendency to become bitter noticed in certain red wines may be obviated by heating them to a temperature of 60° C. *Pharm. Centralbl.* 13, 445.

Method of detecting Fuchsine in Wine, Syrup, &c.—G. ROMEI shakes up in a test tube 4 to 5 cc. of the syrup to be tried with the same quantity of amylic alcohol and then allows the mixture to settle. The alcohol collects after a time on the top of the syrup and is red-coloured if the syrup contains fuchsine, but colourless in the absence of this substance.

When wine is to be tested for fuchsine it is necessary first to precipitate the natural colouring matter by means of lead acetate, and only after that to proceed as in the case of syrups.

The smallest quantities of fuchsine are detectible by this method. *Polyt. Centralbl.* 1872, 1437.

Natural and Condensed Milk.—L. P. MERTIAN considers that natural milk is of uncertain quality and much subject to adulteration, and is frequently taken from diseased cows ; whilst condensed Swiss milk is pure and of uniform quality, cannot be adulterated by the retailer (being sold in hermetically sealed vessels), is always at hand, and can be kept for a long time without deterioration. Great care, too, is said to be exercised in the selection of the cows yielding the milk employed, and in the maintenance of their health. *Les Mondes, xxxi.* 96.

Cheese (Gruyere and de Brie).—The mode of cheese-making practised by the firm of Marion Trochain at Châlons-sur-Marne is described ; this cheese has a high repute in the Paris market. To the establishment is attached a pork-rearing institution where pigs are fed on the whey conveyed thither by pipes. *Revue Hebdomadaire de Chimie, April* 4, 1873.

Transformation of Cellulose and its Isomerides into Sugar.—GIBOU DUSART and BARDY have patented a process whereby sugary and dextrinous substances are produced at once from starch, cellulose, &c., in a state of great concentration and in an almost colourless state (without the use of animal charcoal). The materials to be converted (potato cellulose, coverings of the cellules of rice, &c.) are heated with water containing from ½ to 3 thousandths of sulphuric acid, either in a bath or in an autoclave with a steam jacket ; for starch 1,000 parts of water and 2 of sulphuric acid are used to 2,000 of starch considered as dry, the heating being kept up rapidly to 3-4 atmospheres pressure : in two hours the transformation is complete ; the fire is withdrawn and the liquor filtered hot ; a limpid liquor at 30° B. is thus obtained ; but still more dense solutions can be prepared by using less water. For gummy matters in an almost dry state the same process is adopted, but the time of heating and the quantity of water are different. *Bull. Soc. Chim. Paris, xix.* 476.

Dextrin.—BARFOED finds that glucose can be determined in presence of dextrin by boiling the suspected liquid with a solution of acetate of copper, containing free acetic acid, whereby suboxide of copper is thrown down by glucose but not by dextrin, cane-sugar, or milk-sugar. (Care must be taken that the solution is not too concentrated in the case of the two last, otherwise slight reduction of the copper salt may take place.)

Dextrin is capable of undergoing fermentation, producing alcohol, but much less rapidly than glucose ; elevation of temperature assists the fermentation ; it does not appear that any glucose is formed from the dextrin during the process. *Journal f. Prakt. Chem. vi.* 334.

Purifying and Decolorizing of Beet-root Juice.—In order to avoid the somewhat expensive bone-black treatment, Tessié du Mothay recommends to treat the juice, syrup, &c., with the hydrosulphites of the alkaline earths and sulphite of alumina. *Dingler's Polytech. Journal, ccvi.* 499. *From Journal des Fabricans de Sucre.*

Estimation of Fat in Milk.—MACNAMARA heats 10 cc. of milk with an equal bulk of alcohol and ether to 180° F. for two hours in a sealed tube. After cooling, the tube is opened, the fluid part allowed to run off, and the solid contents of the tube exhausted with boiling ether, which is added to the fluid part. The whole liquid is then evaporated until about 10 ccs. are left, and then treated with ether, the resulting ethereal solution of fat being separated from the aqueous layer and evaporated to dryness in a weighed capsule. *Chemical News*, 1873, 242.

Adulteration of Bread.—EULENBURG and VOHL some time ago stated that certain specimens of bread from the neighbourhood of Maestricht (Belgium), contained zinc, which had most probably been introduced in the form of zinc sulphate. This statement is contradicted by Fasbruder. Of course, the contradiction has reference to the above specimens only, and leaves intact the fact, that the addition of zinc vitriol is not an unknown custom in some parts of the continent. *Dingler's Polyt. Journ. ccvi.* 475.

[*Note by Abstractor.*—We believe this "spicing" is not practised in England, but we are sorry to say that some of our bakers are rather too well acquainted with the use of sulphate of copper. R. G.]

"Shrotbrod," its Composition and Preparation, and its influence on Health.—H. VOGEL points out the necessity of employing the entire meal for bread-making. It deserves mentioning, that as long as four centuries ago an Englishman, Thomas Tryon, censured bread made of fine flour as being harder to digest than the commoner sort containing more or less bran. *Dingler's Polyt. Journ. ccvi.* 480.

Public Analysts under the new Act.—The "Chemical News" states that "the practice of appointing medical men as public analysts, which is actually taking place, is beginning to bear grotesque fruit." Cases of gross "official ignorance" are cited which "call for the interference of the government." *May 23rd*, 1873, 258.

[*Ne sutor ultra crepidam :* it certainly does not appear to be generally known that the ordinary training of a medical man in no way fits him to perform quantitative analytical work, even of the simplest description, and that in order to become able to do such work properly a lengthened period of training, lasting over years, is indispensable.—CHEM. ED. P. M.]

Examination of Butter.—CAMPBELL BROWN gives direction for testing butter, as to its freedom from adulteration with other fatty matters, &c., basing his methods chiefly on the result

of observations and experiments made by himself. *Chemical News, xxiii.* 1.

J. A. WANKLYN considers many of the operations recommended in the above paper to be "utterly delusive," but assigns no reasons for his opinion. *Chemical News, xxiii.* 18.

Rice Malt.—G. EBERT prepares malt from Italian rice, and finds it as suitable for the purposes of beer brewing as barley malt. It contains about 18 per cent. of sugar. The author recommends a mixture of 1 part of rice flour (best together with the bran) and 5 to 6 parts of barley malt, as answering all the purposes of pure rice malt, which is rather expensive. *Polyt. Centralbl.* 1872, 1374.

Preservation of Wood by Tar.—MELSENS impregnated blocks of wood (40 centimetres long and 25 in diameter) with tar by alternate heatings and coolings; they were then kept two years in a corner of a garden in earth saturated with the products of a urinal, and were unaltered: on breaking across it was found that lines were noticeable where the tar had not penetrated completely; the one set of split halves were kept some years in ordinary earth, the others carefully preserved; they were then steamed at 100° for twelve hours, quickly cooled in water, frozen, and left out in the open air all winter, at the end of which time they were unaltered. They were then placed in a wet situation in a garden, then on an isolated building, and then in sandy soil under a rain-water tub. Finally, after twenty years' exposure to varied deteriorating agencies, *no change whatever was produced in them.*

By utilizing the mechanical force of condensing steam, or of the atmosphere, wood may be wholly or partially injected with tar (or other preservative agents); when not preserved the natural course of decay is along the direction of growth, and not across it; the direction in which the preservative body is forced into the wood is the same. When the wood is only superficially injected, it is desirable that it should be shaped into the required form before applying the preservative process. *Moniteur Quesneville*, 1873, 73.

Coffee with Milk.—MARCHAND states that whilst milk is a highly digestible aliment, and coffee infusion alone is a stimulant and tonic that aids digestion, the two together form a most indigestible substance, the tannin in the coffee converting the albumen and caseine into a kind of leather. *Café au lait*, in fact, is only leather soup, and hence frequently produces indigestion and other inconveniences, especially in females. *Les Mondes, xxxi.* 287.

Propylamine a Specific for Acute Rheumatism.—PIROTAIS DE FOUJERES records three cases where this disease was cured in a remarkable manner by the following prescription:—

[1] Propylamine	4 grammes
Tincture of cannelle . .	25 „
Syrup	50 „
Orange flower water . .	10 „
Distilled water	100 „

Four or five spoonfulls being taken daily. *Les Mondes, xxx.* 537. From "Le Moniteur des Hôpitaux."

New Lint.—LAUTIER prepares a balsamic lint by impregnating ordinary lint in a mixture of tincture of aloes and balsam "du commandeur," 250 grammes each; ergotine (extr. hyd. alc.), 30 grammes; neutral glycerine, 200 grammes. This lint keeps well (best wrapped in tinfoil); when required for use it is moistened with pure water or dilute alcohol, and is damped from time to time. *Les Mondes, xxx.* 629.

Curara-like Poisons.—Rabuteau states that the iodides of tetramethylammonium and tetramylammonium act on animals exactly like curara, preventing motion, yet not affecting the sensibility. The energy of these compounds is great, a few centigrammes sufficing to kill a dog in a few minutes. *Les Mondes, xxx.* 621.

Bamboo Poison.—The natives of Java are stated to employ the thin black filaments occurring at the points of the bamboo as a sort of mechanical poison; these are armed with very small barbs, and when mixed with the food or drink of the intended victim, slide into the respiratory organs (*sic*), and set up a fatal inflammation of the lungs. *Les Mondes, xxx.* 584.

Septicæmia.—BRUNIUS has dialysed the blood of patients suffering from typhoid fever, also that of pork or beef in a putrid state, allowing the liquid to diffuse into distilled water at a gentle temperature. After fourteen hours the diffusate became lactescent, and contained multitudes of vibros, bacteria, &c., these being much more numerous than in the liquid remaining inside the dialyser. This liquid, when injected into rabbits, gave rise to septicæmia; but the diffusate did not possess this power; whence the author concludes that the virus of putrid infection is not a substance capable of dialysis (in which respect it resembles albumenoid substances), and that it does not consist of organized ferments of the nature of vibrios, &c., but that these are the result (and not the cause) of putrid alterations. *Académie de Médecine, March 11th*, 1873.

Carbolic Acid as a Disinfectant.—P. C. PLUGGE has made a great number of trials with various disinfecting agents, and finds that carbolic acid is superior to all other materials usually employed for disinfecting and deodorizing purposes—such as iron protosulphate, chloride of lime, and potash permanganate. He further finds that the concentration of the acid to be used ought to be at least 1 per cent. *Polyt. Centralbl.* 1872, 1376.

§ 5. *Fuel, Illumination, Photography, &c.*

Mineral Oils of Buxière-la-Grue and Cordesse.—J. JOFFRÉ finds that these oils (derived from bituminous schists) much resemble American petroleum, the chief difference being that whilst petroleum is mainly made up of hydrocarbons homologous with marsh-gas, and indicated by the formula $C_n H_{2n+2}$, the schist oils contain hydrocarbons of the olefine series, $C_n H_{2n}$, in proportion about equal to that in which the marsh-gas hydrocarbons are present. The olefine hydrocarbons combine readily with sulphuric anhydride or bromine, and are attacked by nitric acid; the marsh-gas hydrocarbons resist the action of these reagents. Neither benzene nor naphthalene are present.

Oil from Buxière-la-Grue (Allier) gave the following proportions of volatile substances:—

Loss by heat at	140°	0·5	per cent.
„ „	160	5·3	„
„ „	180	25·2	„
„ „	200	45·5	„
„ „	220	63·3	„
„ „	240	78·7	„

It had the specific gravity 0·815.

Oil from Cordesse (Saône-et-Loire) gave:—

Loss by heat at	140°	0·1	per cent.
„ „	160	2·0	„
„ „	180	24·3	„
„ „	200	71·5	„
„ „	220	91·0	„
„ „	240	96·0	„

and had the specific gravity 0·800.

The schist of Buxière-la-Grue contains (the ash being subtracted):—

Carbon	70·34
Hydrogen	7·24
Oxygen and nitrogen . . .	20·42
	100·00

On comparing this composition with that of most coal, it is noticeable that the hydrogen is present in greater proportion with reference to the carbon in the schist than in coal, whilst the hydrocarbons from the schist also contain more hydrogen in reference to the carbon than those derived from coal-tar, where benzene, naphthalene, anthracene, and other hydrocarbons comparatively poor in hydrogen occur in some quantity. *Bull. Soc. Chim. Paris, xix.* 547.

Production of Petroleum in America.—The produce in 1872 was greater than in any previous year. From Pennsylvania 5,713,365 barrels of 45 gallons each were exported, the total produce of this district being 6,539,000 barrels, that of Canada 530,000, of West Virginia, Ohio, and Kentucky 325,000 barrels—in all 7,394,000 barrels, or 20,000 barrels per diem. The United States exported in 1872 2,951,210 barrels of refined oil, 363,736 of crude, and 182,298 of naphtha. Total, 3,497,344 barrels. *Les Mondes, xxxi.* 142.

Ceresin.—An article was prepared under this name by a Vienna druggist as substitute for wax in pharmaceutical preparations. Chemical analysis proved this substance to be nothing else but paraffin. *Vide* "Practical Magazine," No. 3, p. 223. *Pharmaceut. Centralhalle*, 1872, *No.* 41.

Manufacture of Hydrogen for Industrial Purposes.—GIFFARD employs two vessels, made of sheet iron and lined with fire-bricks. One forms a sort of fireplace, or stove,

[1] *i.e.* trimethylamine. *Vide* "Practical Magazine," June, 1873.

where coke is burnt in a limited supply of air ; the mixture of carbon oxide and nitrogen thus produced is passed through the second, which is filled with fragments of iron ore. The iron thus becomes reduced to a spongy mass, through which steam is then passed (after shutting off the current of carbon oxide and nitrogen), whereby hydrogen is generated in large quantities. With an apparatus containing two or three tons of ore, a balloon can be readily inflated with 100 cubic metres of nearly pure hydrogen in a short time. *Moniteur Quesneville*, 1873, 156.

§ 6. *Electricity, Magnetism, Telegraphy, &c.*

New Pile.—ZALIWSKI employs a pile with two porous cells ; the innermost contains nitric acid and a rod or plate of carbon ; the next contains sulphuric acid ; this is placed in an outside vessel containing strong ammonium chloride solution and a zinc plate. What the special advantages of this arrangement are is not stated, nor are any measurements given of its electromotive force or internal resistance, which must be considerable, nor is any idea given as to its durability or cost. *Les Mondes*, *xxxi.* 416.

A simple constant Battery.—BOTTOMLEY has devised the following simple construction for constant batteries : A square wooden tray is lined with lead, on which copper is deposited by electrolytic process ; this tray serves as the cupric element. In the corners of the tray four little wooden blocks are fixed, which support a perforated zinc plate ; this is covered with parchment paper on its downward face and its sides. When it is required to set the cell to work, the tray is filled with a concentrated solution of zinc sulphate, and copper sulphate crystals occasionally added. A battery made up of these cells requires no special superintendence. About 80 cells of this construction have been in uninterrupted use for three months in the Physical Laboratory of Glasgow University, and have during that time completely retained their constancy. *Scientific American*, 1872, 364.

New Mirror Galvanometer.—V. DE LANG describes a new form of galvanometer readily rendered astatic and free from oscillation. *Académie Imp. de Vienne, Jan. 16th*, 1873.

New Galvanometer.—E. DUCHEMIN replaces the needle of a galvanometer by a magnet made of a piece of flexible steel bent into a circle and magnetized : the circle being suspended in a horizontal position, a diameter of it is marked out by a fine wire corresponding accurately with the magnetic axis ; the deviations of the magnet can thus be read off more readily than with a simple needle. *Moniteur Quesneville, iii.* 508.

Apparatus for Multiple Transmission by the same wire.—H. MEYER has constructed an apparatus for this purpose consisting of four (or even more) transmitting instruments, so arranged that the current from each one is successively communicated to the wire and thence to a set of four receiving instruments at the far end ; the greatest synchronism between the motions of the transmitters and receivers is indispensable, and this is gained by a special portion of the apparatus. With four transmitting clerks 100 despatches per hour can be sent, the wire conveying 20 successive currents per second. *Les Mondes*, *xxxi.* 389.

Electric Bells and analogous appliances.—BOULAY and Co. make a speciality of electric bells, the apparatus for which is briefly described : a peculiar modification of battery (pile Boulay) is used, where the zinc is plunged into a solution of common salt with 3 per cent. of flowers of sulphur ; it is stated to possess great constancy and to give rise to no evil odours. *Revue Hebdomadaire de Chimie, April 4th*, 1873.

Wilde's Machine.—WILDE has introduced several improvements into his induction machine, the object of which is to avoid the heating of the armatures through the extreme rate of revolution. With an engine of 10 horse-power to drive the machine, and a speed of 1,000 revolutions per minute, the light produced is equal to 1,200 carcel lamps each burning 40 grammes of oil per hour, or to 9,600 wax candles. *Les Mondes*, *xxxi.* 344, *from Phil. Mag. June*, 1873.

Magneto-Electric Machines.—LANTIN states that five years ago he patented in Belgium a machine differing but little from Wilde's. In 1869, with a model weighing 600 kilogrammes, he obtained a light equal to 1,150 carcel lamps ; this machine became much heated, but since then improvements have been made by which two carcel lamps light per kilogramme of weight of machine can be readily obtained, a result surpassing that of the gramme machine. *Les Mondes*, *xxxi.* 366.

Magnetism and Electro-Magnetism.—CAPTAIN TREVE finds that it is possible to magnetize a bar of steel, not merely by the discharge of a Leyden jar, but also by the induced current of a Rhumkorff's coil ; and hence concludes that the phenomena of magnetism are explainable by the existence of atmospheric currents of electrized air from west to east. Several new experiments on the subject of magneto-electricity are described. *Les Mondes*, *xxx.* 635.

§ 7. *Miscellaneous.*

Indelible Ink.—ENCAUSSE has brought out an ink sold under his name, on which Boussingault reports thus ; the ink is indelible, owing this property to the presence of carbon, which is indestructible by ordinary chemical agents. *Les Mondes*, *xxx.* 625.

E. DUCHEMIN states, on the other hand, that this ink contains *no carbon* in the free state, the colouring matter possessing the properties of Coupier's blue, an aniline colour ; treatment with sulphuric acid, instead of having no action on the ink, produces a green-blue tint ; moreover, the ink does not resist washing with sea water even as well as other varieties of ink, such, for example, as the ink of Mathieu-Plessy. *Moniteur Quesneville, iii.* 510.

Solid Inks.—E. ROY prepares various qualities of inks in the solid state ; by merely placing a small quantity of the powder in water, ink for writing is immediately obtained. One variety, styled *indelible ink*, is stated to resist the action of the most energetic chemical re-agents ; it appears to consist mainly of charcoal and glycerine. For travelling and other purposes, the possibility of dispensing with liquid ink renders these substances valuable. *Revue Hebdomadaire*, 1873, 282.

Polishing Material.—MIGNOT condemns the use of colcothar on account of its price, and because it contains sulphuric acid (?), being prepared by calcining sulphate of iron. He proposes to use finely divided silica instead. From the same material a substitute for meerschaum, a neutral soap, and many other useful products may be obtained. *Les Mondes*, *xxx.* 56.

A clear, flexible Varnish.—PUSCHER recommends a solution of alum soap in oil of turpentine as a specially advantageous varnish for metallic objects which are exposed to high temperatures. Such a varnish does not possess the brilliancy of damar varnish, but it has greater flexibility and resists heat better. The alum soap is prepared by adding a solution of alum to a boiling soap solution as long as a precipitate ensues, washing the latter, and drying. This alum soap is transparent like glycerine soap, and soluble in all proportions in oil of turpentine. *Polyt. Centralbl.* 1872, 1376.

Sugar-Lime as a solvent for Glue.—E. PUSCHER dissolves 1 part of sugar in 3 parts of water, adds ¼ part of slaked lime, keeps the solution at 60°—75° C., shakes up at intervals for several days, and adds 3 parts of glue to 12—15 parts of this sugar solution. On gentle warming the glue dissolves, the solution remaining clear on cooling. The addition of 2 to 3 parts of glycerine is useful, also a drop or two of lavender oil, to remove the strong glue smell. This glue has an effect upon certain colours, changing them to a considerable extent. *Polyt. Centralbl.* 1872, 1439.

Etching on Glass.—DODÉ patents the use of boric acid instead of hydrofluoric acid, the following process being employed : the glass plate is dried on a stone table covered with a cloth, and the polish removed by fine sand ; the required design is then painted on, a varnish of 2 kilogs. boric acid and 50 grammes gum arabic rubbed up with water being employed ; this is allowed to dry, and then heated till the boric acid fuses, when a semi-transparent appearance is communicated to the glass. By mixing up various metallic oxides with the varnish, any required tint may be produced. *Bull. Soc. Chim. Paris*, *xix.* 573.

Powdered Glass Filters.—WEISKOPF employs a layer of powdered glass for the filtration of turbid liquids. *Polytech. Journal*, 206, 243.

Atmospheric Telegraph.—MIGNON and RONART have laid down a "pneumatic despatch" worked by compressed air, the force being derived from the service water of Paris. The cost of water for sending 500 messages a kilometre is said to be about 25 centimes. *Les Mondes*, *xxx.* 539.

Impurities in Butyl Ether and Butyric Acid.—BURGEMEISTER points out that commercial samples of the above substances are much admixed with water and alcohol, together with acetic, propylic, and caprylic ethers. *Polyt. Centralbl.* 1872, 1437.

Perfumed Alumina as a Toilet Material.—BONNAMY prepares a sort of paste consisting of pure alumina

disseminated through glycerine, and suitably perfumed ; this composition is stated to be an admirable cosmetic, cleansing the skin mechanically and not by the action of more or less caustic soaps, and hence preserving a soft and velvety surface on the skin. *Revue Hebdomadaire*, 1873, 273.

Influence of Inactive Solvents on the Rotatory power of Substances.—OUDEMANS finds that the "specific rotatory power" of most substances is not, as usually supposed, independent of the nature of the solvent (that being itself inactive). Saccharose, however, gives much the same result whether dissolved in water or alcohol at 50 per cent., the specific rotatory power being + 66·9 and + 66·4 in these two cases respectively. The points suggested in this paper are of considerable importance to the sugar trade, the use of the rotation saccharometer entirely depending on the assumption that all solvents, themselves inert, do not affect the rotatory power of the substance dissolved. *Annalen der Chem. & Pharm. clxvi.* 65.

Thermo Diffusion.—JEDDERSON applies this term to indicate the fact that if the two sides of a porous diaphragm be at different temperatures a kind of gaseous diffusion is set up from the cooler to the hotter side ; this the author considers as a phenomenon not of the same kind as ordinary diffusion. *Poggendorff's Annalen.*

Carbonic Acid in the Atmosphere.—HENNEBERG finds that 10,000 volumes of atmospheric air contain on an average 3·2 volumes of carbonic acid, the experiments being made at Weend, during the summer of 1872. *Landw. Versuchs-Stationen, xvi.* 70.

FEED-WATER HEATER.

THE fact that the best steam-engines, steamed by boilers constructed on the most approved known principles for securing economy of heat, realize but about one-sixth of the theoretical efficiency of the coal consumed in the furnace, proves that inventors and men of science have still much work to do ; and the present greatly enhanced price of coal—an enhancement generally considered as a permanent one—will not prove an unmixed evil if it operate as a spur to inventive talent, and thus secure for us a better understanding of the laws of heat, and their application as a source of power, than we at present are in possession of. The widespread employment of steam power—an employment yearly increasing, acting as it must to increase the consumption of coal, and, consequently, reduce our stock of it, coupled with the enormous outlay on fuel forced now upon steam users, to the reduction of their profits—an outlay now about doubled in comparison to that of some two years back, owing to the immense increase in coal rates—renders the discovery or invention of some means of economizing heat, especially when employed as a source of power, well nigh a matter of necessity ; and there is, we are glad to think, a greater activity observable latterly on the part of scientific men and inventors in devising, and less supineness on the part of manufacturers in investigating, the merits of new schemes to save fuel. The sources of waste of heat in steam machinery are so manifold, as may well excite some little surprise in the breasts of laymen at the slowness of scientific men to devise means of checking this loss. Heat is lost up the chimney, lost in its transit from the boiler with the steam through the pipes and cylinders ; and immense loss of heat takes place in the exhaust, either to the atmosphere, or in lesser degree in the condenser. Various patents exist for schemes to take the maximum quantity of heat from the exhaust steam as soon as it leaves the cylinder. Such schemes are known as feed-water heaters ; they seize the escaping heat and march it back to the boiler again. They rest on the principle that if, with our present limited knowledge of such matters, a quantity of heat far exceeding that necessary to actuate the piston must pass from the boiler through the engine, then they watch at the exhaust and secure the superfluous heat, or as much of it as possible, and remand it again to the boiler. The various schemes at work at present give results more or less—usually less—satisfactory, according to their design and the care with which the design is carried out.

We place before our readers illustrations of a feed-water heater invented by Mr. R. Berryman, an American gentleman, having offices at 28, Wilson Street, Finsbury, London. It is in somewhat extensive operation in America, and its recent introduction to this country bids fair to prove an extensive one, and to be attended with advantage and success. Mr. Berryman has explained the details of the invention to us, and we have carefully examined it from every point of view, and are satisfied that it may well be classed with the very best heaters at present in practical operation. In the principles of its action it is practically a surface condenser. The exhaust steam is passed through a group of tubes of small diameter, bent to a horse-shoe form, and one set of ends communicates with a steam chamber beneath ; the other ends likewise communicate with the same chamber, which is, however, divided across by a steam-tight partition ; the tubes are enclosed within a casing, which contains the cold water to which the heat of the exhaust steam is transferred during the passage of the steam from the one part of the chamber through the tubes to the other part. The details are very clearly shown in the illustrations. A is the outer casing enclosing the tubes and containing the water to be heated ; this is constructed of boiler plate, and is carefully tested to a safe margin above the working boiler pressure before use ; it is fitted with a curved top riveted securely to the barrel, while below a ring flange is riveted to the barrel A also, and the base of this is fitted to joint with bolts and nuts to the tube plate J ; this tube sheet forms the upper side of the partitioned chamber D, which has its bottom plate H bolted on in a manner similar to that for securing the tube sheet, fitting to the barrel. The exhaust steam enters at the inlet E, passes round through the tubes, giving up its heat in passing to the water surrounding the tubes, and the steam, now condensed into water, escapes through the drain pipes I I (fig. 1) ; because the inventor claims as one of the advantages of his water-heater that the exhaust steam—coming as it does charged with grease and oil from the engine—is not returned to the boiler, its place being supplied by the clean water heated in the casing. Part of the bottom chamber side is shown broken away in fig. 2, to display the partition R dividing the chamber into two spaces. The steam inlet is at E, the outlet for any uncondensed vapour is at G ; but these orifices may be just reversed if convenient. The tube plate J is stiffened by two cross feathers cast with it, shown at S ; while the entire apparatus rests on the legs T, which are fitted with screws to level the heater when fixing it. As a matter of course, in a contrivance so carefully thought out as this shows itself to be, care is taken that the aggregate area of the diameters of the condensing tubes, exceeds considerably the area of the exhaust pipe, and so there is no back pressure caused in the cylinder of the engine, while from the length and number of the tubes, and the great cooling surface thereby secured, the heat in the waste steam is almost entirely retained in the feed-water, and the latter is allowed plenty of time to throw down any deposit due to alteration of temperature before being pumped into the boiler, thus reducing by a good deal the scale formed in the boiler ; while as the water is not delivered to the boiler till it is about 210 degrees of heat Fah., turning on the feed to the boiler does not lower the boiler pressure appreciably. The advantages of excluding the grease of the condensed steam from the boiler is a valuable feature of this apparatus ; because the steam from the boilers of dye-works, and in some other industries, is employed to heat various dye liquors, worts, and for other purposes in which the presence of grease exerts a most injurious influence ; hence, as this feed-heater returns nothing of what left the boiler and passed through the engine but the heat, this feed-heater is eminently suitable for the industries referred to. Boiler insurance companies in America object latterly to open feed-heaters ; therefore this being a close one, it escapes "taboo" on that score. The arrangement of the tubes vertically, effectually provides against any lodgment of condensed water in the tubes, and the tubes themselves have full liberty to expand and contract, so no leaky joints need be apprehended. As to pumping, but little of this is required, so the loss of power here is small. The real test for an invention is the practical result realized from working it ; and the saving of fuel, we understand, attending the use of this feed-heater equals from one-seventh to one-sixth, or from 14 to 16 per cent.

Fig. 4, on page 126, shows a Berryman feed-heater in connection with a horizontal non-condensing Corliss engine at the Navy Yard at Washington D.C., and on which Mr. E. Fithian, Chief Engineer, U. S. N., reported that the temperature of the feed when leaving the condenser was 204°, and that the saving of coal secured by its use equalled 16 per cent., the feed when entering the heater being but 42° Fah. The Gilbert Manufacturing Company, Ware, Massachusetts, reported a gain of 13 per cent., and temperature of feed to equal from 208° to 212° Fah., or boiling point at atmospheric pressure. Messrs. Garner and Co. of New York, a firm running eight large cotton mills and two calico printing factories, have in use seven of these feed-heaters of sizes ranging from 42 in. in diameter and 8 ft. high, to 52 in. diameter and 20 ft. high, this latter being the largest size yet made.

Certain advantages have been derived from the introduction

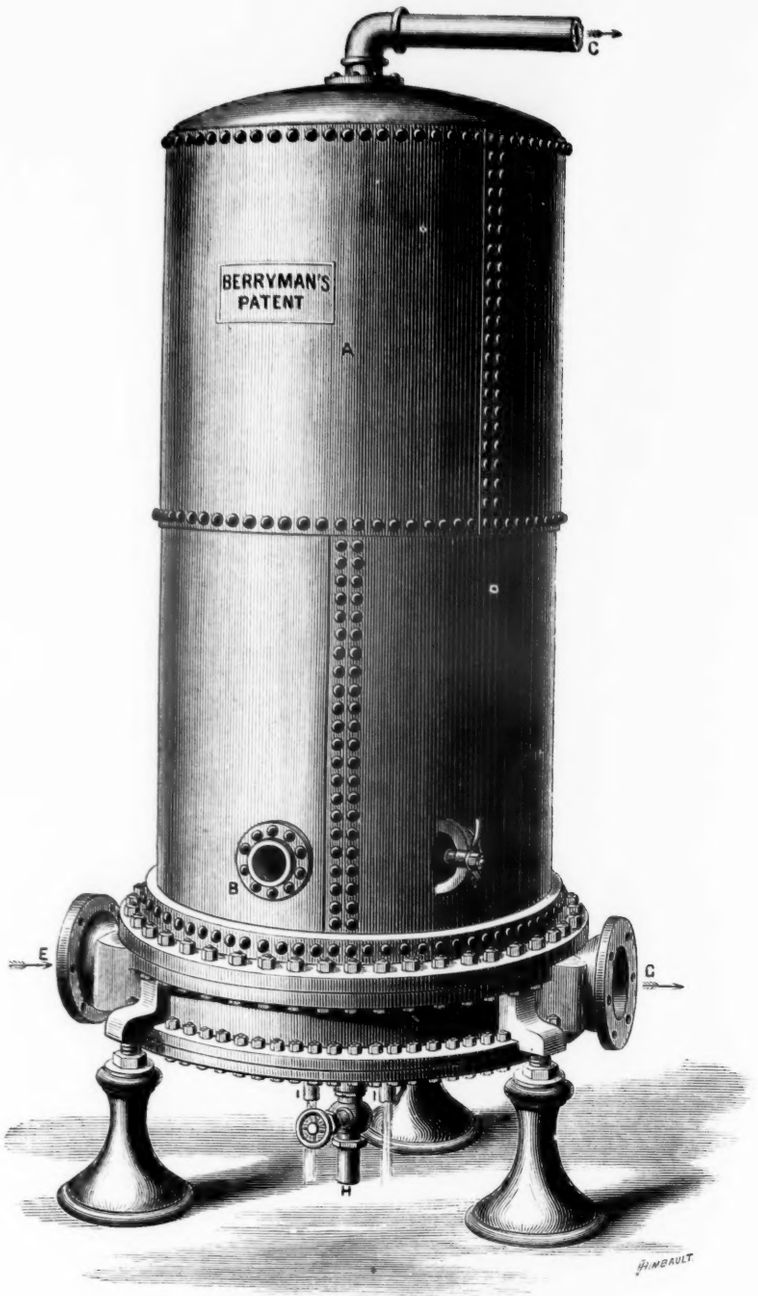


FIG. 1.—BERRYMAN'S HEATER.—EXTERIOR,

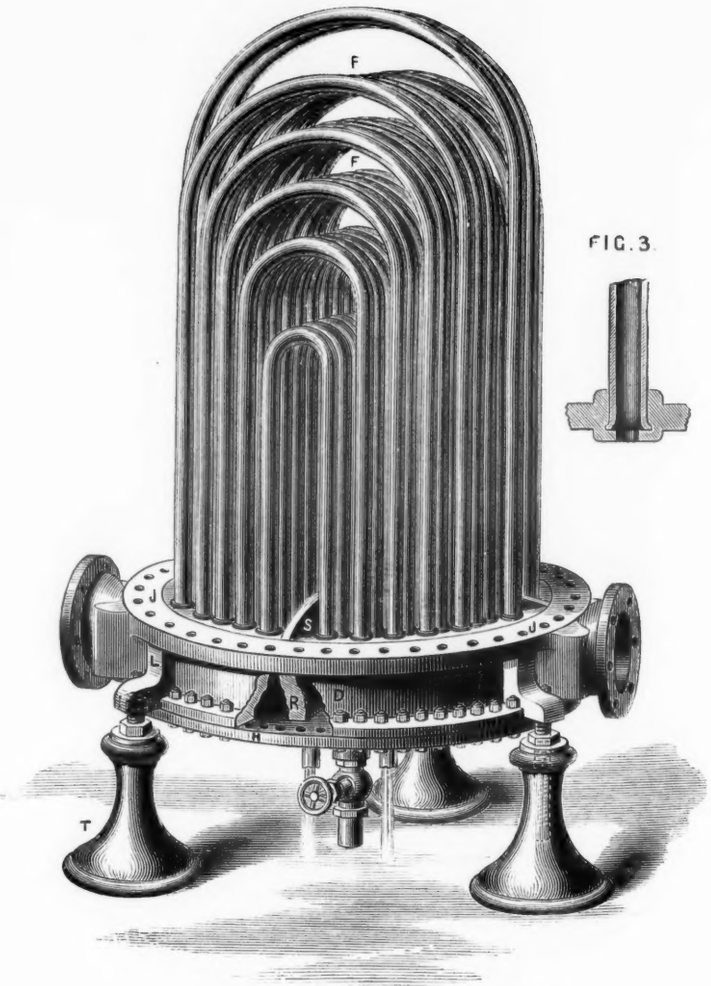


FIG. 3

FIG. 2.—BERRYMAN'S HEATER.—INTERIOR.

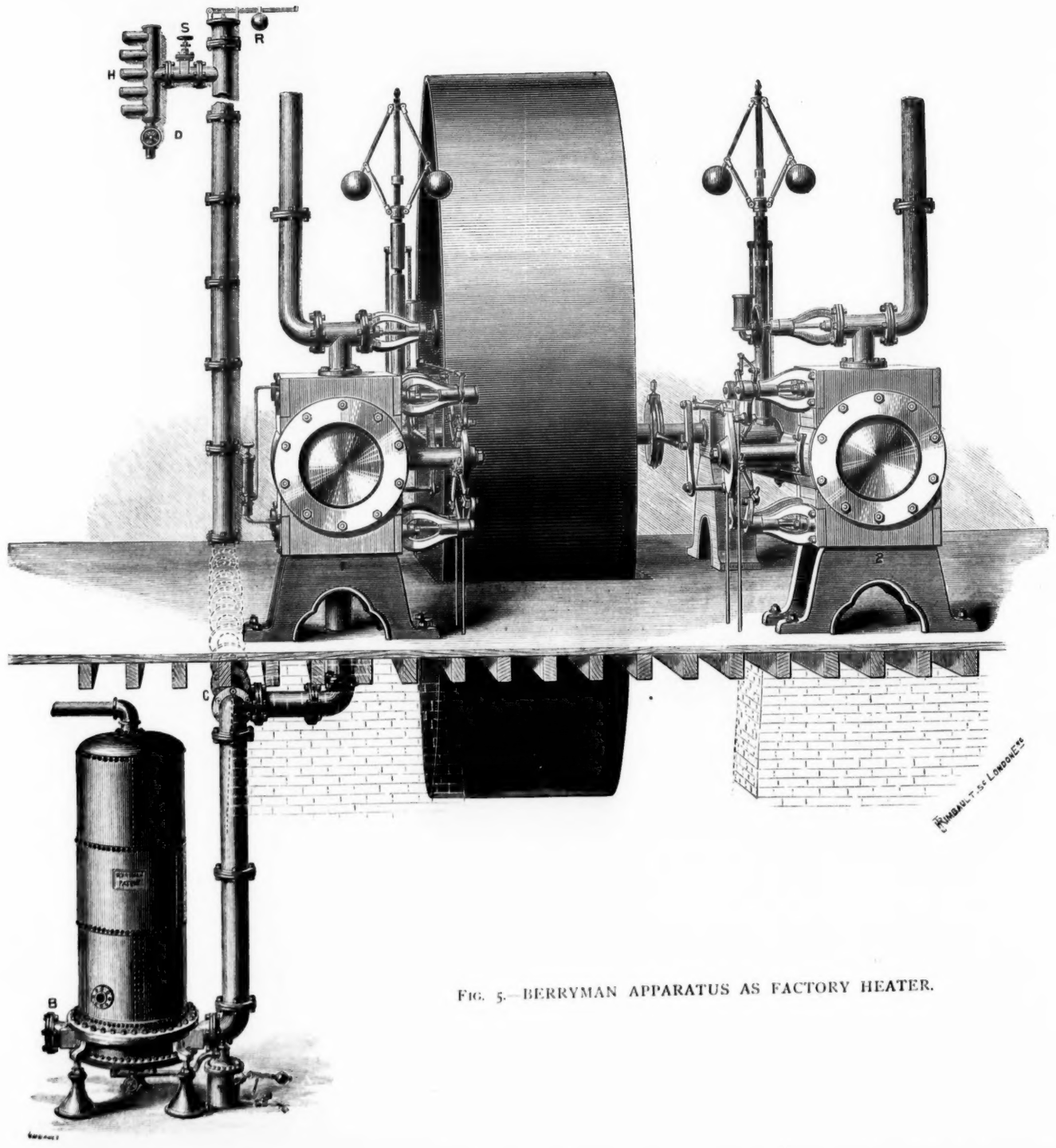


FIG. 5.—BERRYMAN APPARATUS AS FACTORY HEATER.

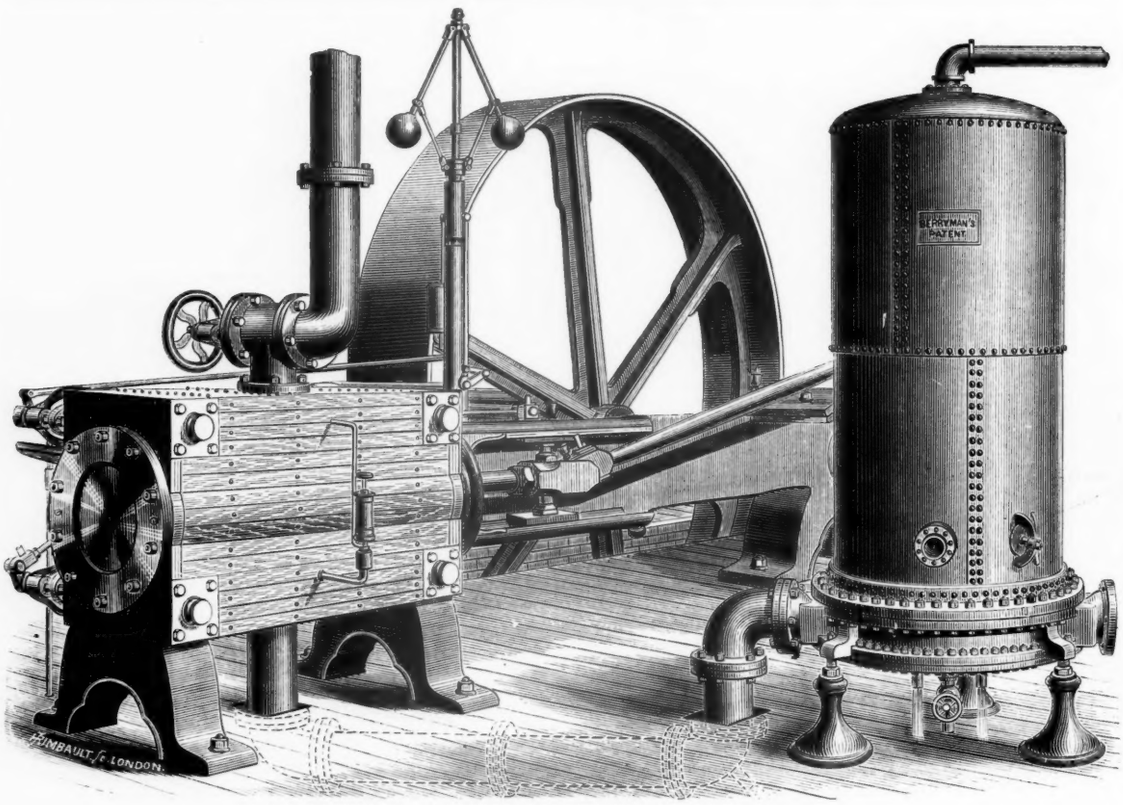


FIG. 4.—BERRYMAN FEED-WATER HEATER TO HORIZONTAL ENGINE.

of one of these heaters between the cylinder of a condensing engine and the "condenser" properly so called, the condensed water being forced from the hot-well through the heater and thence into the boiler. In certain processes of particular manufactures two of these apparatus may be employed conjointly, one being used as a heater, the other, in inverse action, as a condenser, care being taken with the latter to work it really as a surface condenser, by maintaining a plentiful circulation of cold water round the tubes.

This apparatus has been turned to account in America in another way, too, viz. as a factory heater. The climate in winter is so trying and severe in the United States and in Canada as to render efficient warming of buildings inhabited by human beings a matter of necessity, and our cousins employ the exhaust steam of their engines extensively for this purpose. In one case we may refer to, an engine and heater at Mechanics Cotton Mills, Fall River, Massachusetts, was fitted with a Berryman heater. The illustration shows the engine; it is a double-cylinder engine rated at 1,000 indicated horse-power; cylinders are 30 in. diameter, 6 ft. stroke, and shaft runs at 50 revolutions per minute. Fly-wheel is 30 ft. diameter and its belt face is 9 ft. wide, running three 3 ft. belts. The steam is drawn from but one end of one cylinder for heating purposes, the back pressure is 1½ lbs.; the mill is thoroughly warmed and the water is fed to the boilers at 200° Fah. The exhaust steam is conveyed into the pipe at C, the pipe having branches to the different floors and to the feed-heater, the outlet of which is covered by the plate B, so that all the steam uncondensed and discharged by the steam trap at T passes into the upper pipes H and warms the factory, after which it is allowed to escape at R. At D is a special inlet valve to admit steam direct from the boiler to the factory when the engines are standing. During the summer season the valve S is closed, the lid B of the outlet of the heater removed, and the heater worked in the ordinary way. The saving of coal derived from the substitution of a Berryman for the old open feed-heater at this factory, we have been told, equals 1,800 lbs. or about ⅘ of a ton per day. The dimensions of this heater are 4 ft. diameter by 12 ft. high. The tubes of the Berryman heater are secured in a very simple, cheap, and secure manner into the tube plate. The tube plate is of cast-iron, and each tube hole has a thickening fillet cast round it. Each hole, after its being bored to receive the tube, is undercut, fig. 3, and the tube, when put in place, is bevelled out with a suitable mandril.

Mr. Berryman has, we believe, supplied his heaters to various eminent firms in this country, amongst others to Messrs. Westray and Forster of Barrow-in-Furness, and to Messrs. Neil and Co. of Leeds.

THE PRACTICAL NOTE-BOOK OF TECHNICAL INFORMATION USEFUL TO STUDENTS AND WORKMEN.

(47.)

DESIGN for Ornamental Wood-work, with Working Lines and Centres.—Continuing the series of designs for ornamental work in this department, we give, in fig. 190, another design for a single eavesboard. Let *a b* be the height of the board; divide it into seven equal parts, and bisect the fifth and sixth parts in the point *c*. Divide *c* 5 in the point *d;* and from *c* as a centre, with *c d* as radius, describe the circle *c d*, the diameter of which, its multiples or subdivisions, give the various dimensions. From the point 5, with the diameter of the circle *c d*, set off to the point *e*, and through *e* draw a line *f g* at right angles to the line *a b;* making *e f*, *e g*, each equal to four times the diameter of the circle *c d*. Through *f* and *g* draw lines parallel to *a* and *b*, from *f* and *g* as centres, with *c d* as radii, describe semi-circles as shown, and from the extremities of the diameter of these draw lines *h i*, *j k*, parallel to *a b*. From *h* and *j*, with distance equal to the diameter of the semi-circle *h g*, set off to the points *l* and *m*, and from these draw lines *m n*, *l o*, parallel to *a b*. With distances equal to the diameter of the circle *c d*, or half the distance 5 6, as radii, describe parts of circles touching the lines *m n*, *l o*. With

the distance 4 3 as radius, and from the point 4 as centre, describe the arc *p q*, cutting the circles described from the centres *r s*. With the radius *c d*, from the point *b*, the lower termination of design, set off to the point *t*, and from this as centre, with the same distance *c d*, describe the circle as shown. Bisect the distance 1 2 in the point *u*, and from this as centre describe the arcs, touching a line drawn through *u* parallel to *f g*. From the point 4 as centre, with 4 *i* as radius, describe the arcs joining *v v* with *i* and *k*. From *u* as a centre, with *u i* describe the semi-circle *w w*, and from *w w*, parallel to *a b*, draw lines which join with arcs described from the centre 4, and with the lines *o* and *u* produced; bisect the arcs 3 *p*, 3 *q*, in the points *y y*, and from these as centres, with *y y* as radii, describe arcs *y z*, *y z*. Finish as in the drawing.

In fig. 191 we give the design of a paling or palisade, of which *a b* is the height. Divide this into eight equal parts, and through the fourth of these draw a line *c d*, at right angles to *a b*. Divide the seventh and eighth of these, as *a* 7, into four equal parts —one of these parts is the "standard" for all the dimensions. From the point 7, with three of these parts set off to the point *e*, and through this draw a line parallel to *c d*. From the point 4, with a distance as 7 *a*, one of the parts, on *a b*, set

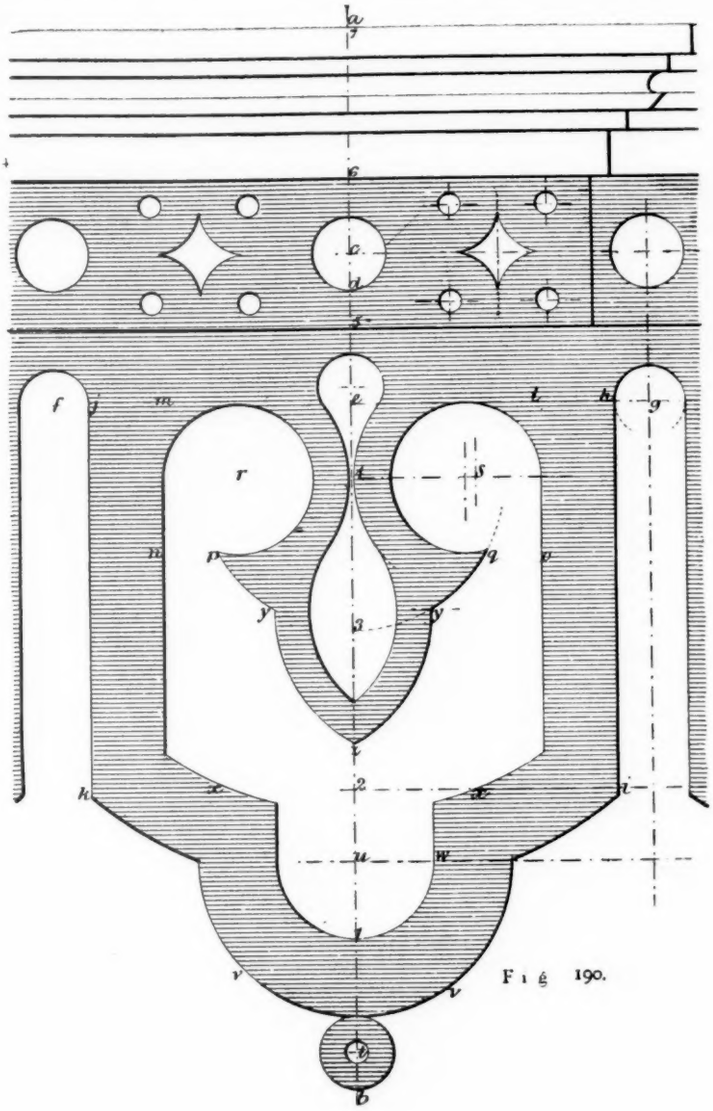


Fig. 190.

off on the line *c d* to the points *f*, *g*, *h* and *i*, and through these draw lines parallel to *a b*; these are the "centre lines" of the principal parts of the design. Through the point 6 draw a line parallel to *c d*; and from 6, with half of the distance 6 *a*, describe the small circle as shown; do the same at the corresponding points on the centre lines through *g*, *f*, *h* and *i*; and also at corresponding points on a line drawn through the point 2 parallel to *c d*. Join these circles by double lines as shown, the distance between which may be about equal to half of the radius of the small circle 6. Divide the distance *f g* in the line *c d* into two equal parts, and at the point *j*, and through it, draw a line parallel to *a b*; do the same between *k* 4, 4 *h*, and *h i*. Bisect the distance *j n* in the point *o*, and with the radius of the circle 6, put in the semi-circle as shown. Bisect *o n*, *o j*, in the points *p* and *q*, and join the semi-circle at *o* with these; do the same at all the corresponding lines drawn through the points *j k l* and *m*. Divide the first part, on *a b*, namely, *b* 1, into four equal parts; and through the third of these, as *r*, draw a line parallel to *c d*. From *r*, set off to *s* and *t*, distances equal to the diameter of the circle 6, and parallel to *a b* from *s* and *t* draw lines *s u*, *t v*, and make *t v* equal to twice the diameter of the circle 6; through *v u* draw a line parallel to *s t*; from *s t*, *u* and *v*, describe the arcs and circles as shown; do the same at all the corresponding points. Through the point *w* on 7 *a* draw a line parallel to *c d*; through the points between 7 and *a*, draw lines parallel to *c d*. From *w*, with the radius of the circle 6,

describe a semi-circle; bisect *w y*, and from *x* with radius *x y*, and the points between *y* and *w*, describe the semi-circle *a' d'*; join the extremities of this where they cut the line *a' b'* with parts of small circles shown, the radii of which are equal to the radius of the circle 6. With the distance *w c'* as radius, join the small arcs *d'' e'* with other arcs *e' f'*, *d'' f'*, from the centres *g' h'*.

In fig. 192 we give a design for a circular ornament in metal or wrought-iron work. Let *a b c d* be the inner circle. Draw the diameters *a c d b*, and divide these each into three equal parts in the points *e f*, *g* and *h*, and through *e f*, parallel to *b d*, draw lines; and through *g* and *h*, others parallel to *b c*. Draw lines from the points as *i* and *j*, *l* and *m*, to the centre *k*. Divide *k i* into two equal parts in the point *n*, and from *k* with *k n*, describe a circle as shown. Bisect *n i* in the point *o*, and from *k* as a centre with *k o* describe a circle. From *o* with the distance *o i*, or *o n*, set off on the circle *o* to the points *p* and *q*. From *p* and *q* as centres, with *p i* as radius, describe the arcs cutting in *i* and *r*. Do the same at all the other lines corresponding to *k i*; and the leading curves will thus be obtained, which finish as in the drawing. The method of finding the arcs of the leading curves of the circles *s* and *p* is shown in fig. 193; two diameters *a b*, *c d*, being drawn at right angles through the centre *e* of the circle, *a b c* and *d* being the centres of the arcs. The curved parts at *f* being parts of circles which touch the line *e f g* drawn through the point of intersection, as *g*, of the two arcs (the curves of the circles as *t*, fig. 192), are found as shown in fig. 194.

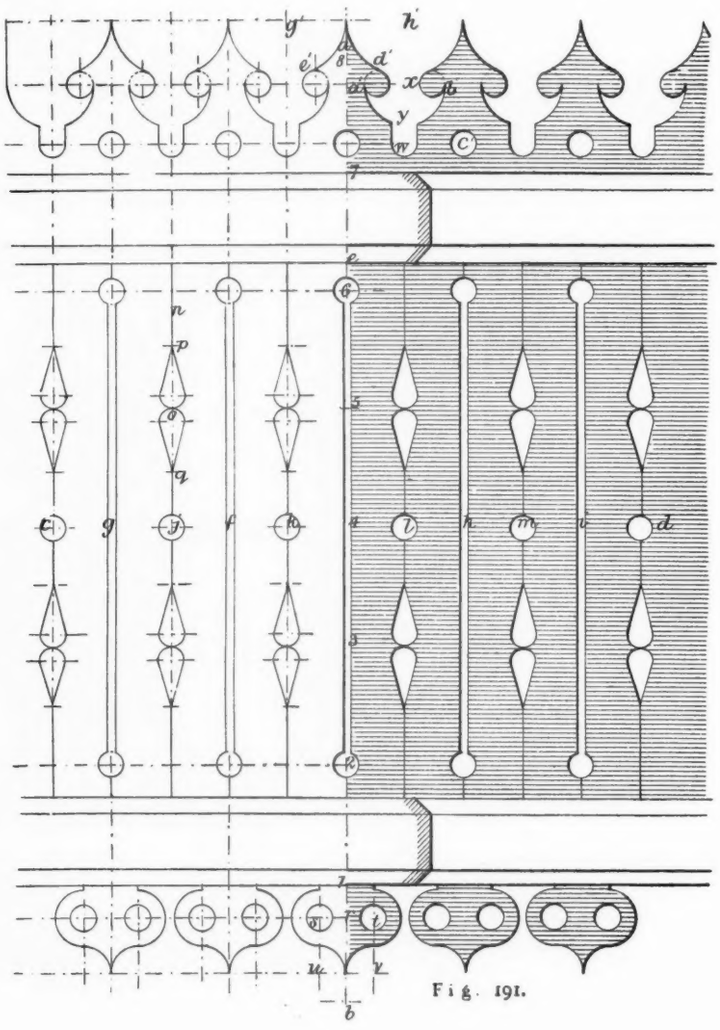


Fig. 191.

The two diameters *a b*, *c d*, are drawn at right angles through the centre of the circle, and the lines *e f*, *g h*, through points bisecting the quadrants as *f*; the centres of the arcs, as *i* and *j*, are at *e f*, *g* and *h*. The small curves as at *a* are put in by describing circles the diameter of which is one-fifth part of the radius *k d* of the large circle.

In fig. 195 we give a design for a balcony rail with eaves, of which *a b* is the height. Divide this into seven equal parts, and through the fourth of the points draw a line *c d* at right angles to *a b*. Make the fascia at top equal to the distance between the sixth and seventh points. From the line *d* set off to *e* and *f*, and make *f g*, *e h*, each equal to two-thirds of one of the parts on *a b*, as 7 8. Through the point 2 draw a line parallel to *c d*, and make 2 *i* equal to *e f*, and through *i* draw a line parallel to *c d*. Through *e f*, *g h*, draw lines parallel to *a b*. Make *b j* equal to *e f*, and through *j* draw a line parallel to *c d*, joining *f e*. Bisect 2 *j* in the point *k*, and through *k* draw *m k l* parallel to *c d*. With one fourth of the distance of *g h* or *e f*, set off from the points *j*, *l*, *o* and *m*, on each side of the centre lines, as to *o* and *n*, from 2 and *l*. From these points as centres, as *o* and *n*, with radii equal to *o l*, describe arcs cutting as at *p*, and from *p* describe an arc joining *o n*. Do the same at all the other points, and describe the double arcs. Divide one of the parts into which *a b* is divided, as the lowest part *b* 1, into four equal parts, as in the points of *r* and *s*. With two of these as radius, from the point *k* in centre describe the circle *k t u*, and put in the ornament with the arcs as shown. Through the points 1 *s r* and *q* on the line *a b*, draw lines parallel to *m k l*. With distance *q b*, set off from *q* to *v*, and from *v* draw a line parallel to *a b*. With *r s* as radius, from *v* as centre describe

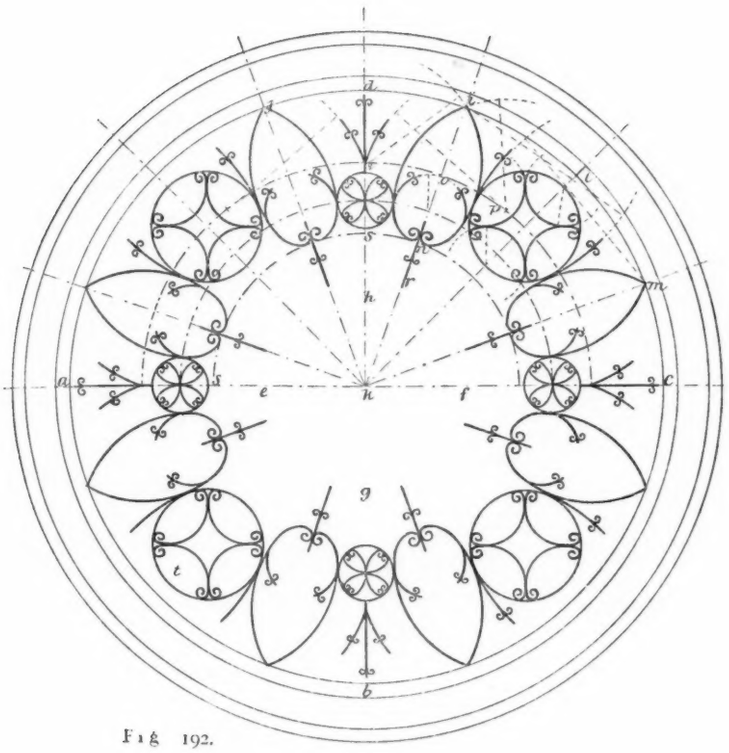


Fig 192.

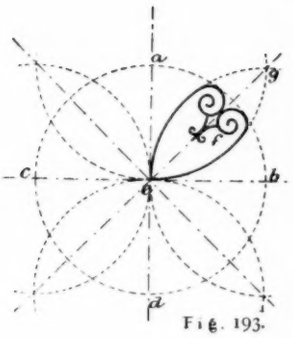


Fig. 193.

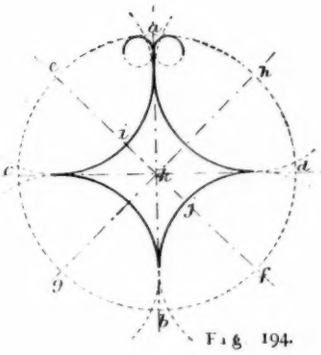


Fig 194.

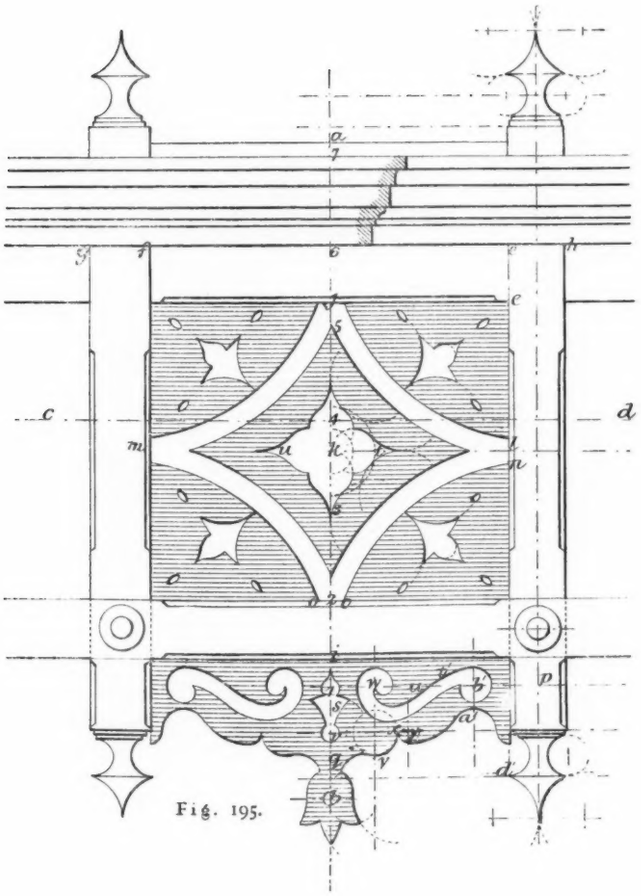


Fig. 195.

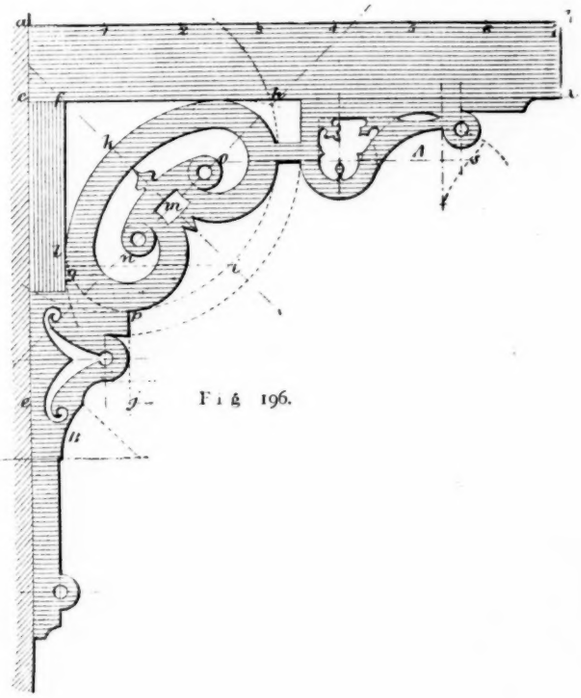


Fig 196.

the arc *v x*. With half of the distance *q v* set off from *x* to *y*, and through *y* draw a line parallel to *v w*, as *y z*; the point *z* is the centre of the arc *y a'*. The arc from *a'* is described with radius *x y*, and through the centre a line to *b'* is drawn parallel to *w v*. The arc *c'* is described from the point *d'*. The dotted lines and radii show how the other parts are put in. The ornaments at *f'* are put in the lines drawn from the centre *k* to the corner points, as *e'*.

A design for a bracket is given in fig. 196. Let *a b* be the breadth. Divide this into seven equal parts; make *a c* equal to one of these, and draw *c d* parallel, and *a e* at right angles to *a b*. Make *c f* equal to half of *a c*, and *f g* equal to 2¼ times *a c*. From the point *f* draw the line *f i*, bisecting the angle *g f d*. Make *c e* equal to four of the parts, as *a b*, and draw a line *e j* parallel to *a b*. With three of the parts, as *a b*, set off in the line *f i* from *f* to *i*. From *i* and *k* as a centre, with radius equal to *i l* describe arcs cutting in the points *g* and *h*. Draw *g h* and bisect *g m*, *m h*, in the points *n* and *o*; and from these as centres describe arcs joining the arcs *i* and *k*, and finish this elliptical-shaped ornament as shown. From *n* draw the line *n j* parallel to *c e*, cutting *e j* in *j*. Divide *j p* into four equal parts. The various dimensions and radii of the arcs of the lower part of the bracket and of the parts A are derived from these divisions; the line *o s* is drawn from the centre *o* parallel to the line *a b*; the dotted lines in this show the centre lines and radii of the various parts.

In fig. 197 we give a design for a perforated panel suitable for wrought-iron work or for wood; if for the latter, the lines will give

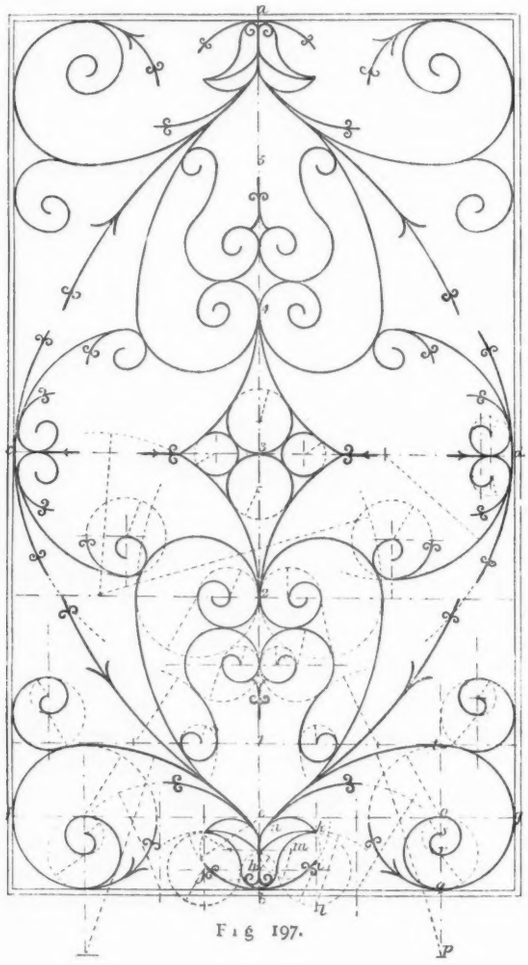


Fig 197.

the centres of the outlines of the various parts cut out. Let *a b* be the height and *c d* the breadth of the panel. Divide the height *a b* into six equal parts, and through the points of division draw lines at right angles to *a b*. Divide the first division between *b* and 1 into two equal parts in the point *e*, and through *e* draw parallel to *c d*, the line *f e g*. Divide *b e* into three equal parts, and through them draw lines as shown parallel to *c d*. From the point *h*, with *h b* as radius, describe the semi-circle, and from *h* set off to *i* and *j* three of the parts into which *e b* is divided, and through *i* and *j* draw lines parallel to *a b*. From *i* and *j* describe arcs terminating at the point *k* in the line *i k*. From *l*, with the distance *l k* as radius, describe the arc cutting the line drawn through the second point, as *b e*. From *m*, with *m k* describe the arc *k n*. From *o*, with *o g* describe the dotted circle; and through *o* draw parallel to *a b* the line *o p*. Bisect *o q* in *r*, and from *r* describe the semi-circle *q o*; bisect *q o* in *s*, and from *s* describe the semi-circle *o r*; bisect *r s*, and from the point of bisection describe the small semi-circle; this will finish the spiral scroll, and the same operation will have to be repeated at all corresponding points of the design. The arc *t n* is described from the centre *p*. All the other arcs are described with radii which are multiples of the divisions, as *b e*, and the lower half of the design has the centre lines so plainly marked that the student should have no difficulty in drawing in the whole.

(48.) **Simple Method of Delineating Architectural Subjects in Perspective, to which the usual scales of equal parts are applicable in reading off Dimensions.**—In continuation of this subject (see notes No. 5, p. 386, No. 7, p. 50), we give in fig. 198 a plan, in fig. 199 an elevation drawn to a scale of ¼ inch to the foot as shown, and in fig. 200 a perspective drawing of the same with diminishing scale. The

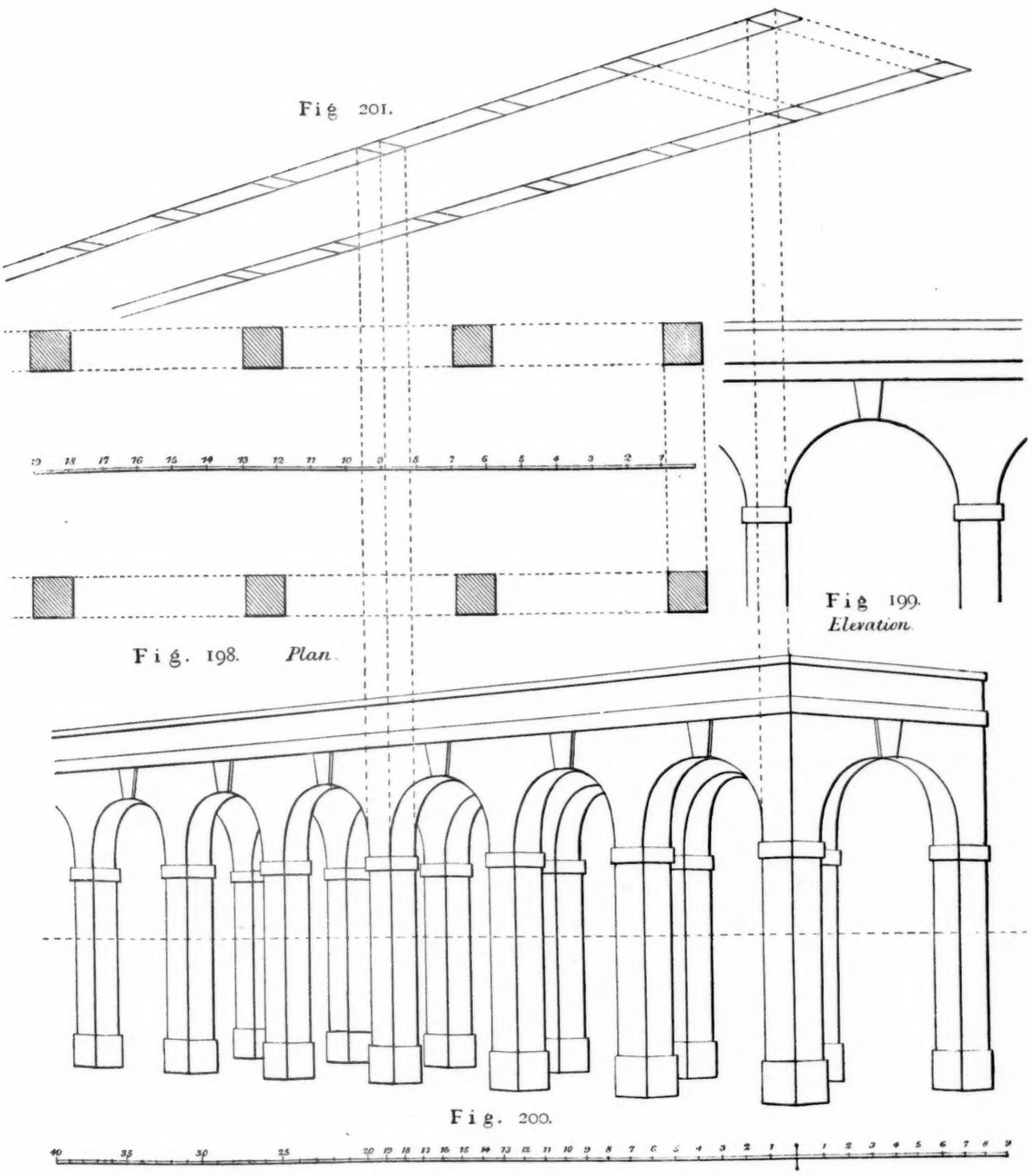


Fig 201.

Fig. 198. *Plan.*

Fig 199.
Elevation.

Fig. 200.

pillars or piers in the face line are measured in the ordinary way already described in the preliminary studies, the internal ones being obtained by the intersection of lines from the skeleton plan in fig. 201.

(49.) **Memoranda on Wrought Iron** (see note, No. 6, p. 430.—*Strength of Wrought-Iron Plates.*—From the experiments of Mr. Hodgkinson, it was shown that "the resistance of plates of the same length and breadth, but varying in thickness, was nearly as the cube of the thickness; or more nearly as the 2·878 power of it. Thus a plate of double the thickness of another would resist flexure or buckling with seven or eight times the force applied in the direction of its length." The resisting powers of plates to a force of compression will vary as the breadth multiplied by same power of the thickness when the length is the same. Let b b be the respective breadths; d d the thicknesses; m m the weights of greatest resistance of two plates of the same length; and n the power which may be considered as constant, when the material is not over compressed. We have then $b\,d^n : b\,d_n :: m : m$, whence $\frac{b\,d^n}{b\,d^n} = \frac{m}{m}$.

The following table gives some of the results of the experiments.

Strength of Wrought-Iron Plates.

Name of places.	Mean breaking weight in the direction of the fibre, in tons per square inch.	Mean breaking weight across the fibre, in tons per square inch.
Yorkshire	25·770	27·490
,, ...	22·760	26·037
Derbyshire	21·680	18·650
Shropshire	22·826	22·000
Staffordshire . . .	19·563	21·010

Length of the plates.	Dimensions of section in inches.	Weight of greatest resistance in lbs.	Weight per square inch of section in greatest resistance in tons.	Value of n.
10 ft. 0 in.	3·00 × 1·51	46,050	4·538	2·622
	3·01 × ·766	7,793	1·508	
10 ft. 0 in.	3·00 × 1·51	46,050	4·538	3·073
	2·99 × ·995	12,735	1·911	
7 ft. 6 in.	3·00 × 1·53	91,746	8·923	2·898
	2·983 × ·5023	3,614	1·076	
	3·005 × ·9955	29,619	4·425	3·064
	2·983 × ·5023	3,614	1·076	
5 ft. 0 in.	3·01 × ·995	54,114	8·066	2·735
	2·98 × ·507	8,469	2·502	

WROUGHT-IRON ARMOUR-PLATES.

The extensive use of thick plates in the construction of warships and of fortifications, and their increasing use in various engineering works, has directed the attention of practical men to the investigation of their properties and strength. The following table and remarks are taken from a paper communicated by Mr. Fairbairn to the "Institution of Naval Architects," and show the result of his experiments:—

Tensile Strain.

Approximate thickness of plates in inches.	Mean density of plates.	Mean breaking strain, per square inch in tons.	Mean elongation per unit of length.	Mean work u, for unity of length section, done in causing rupture, in ft. lb.
1½	7·7471	24·453	·1769	4844
2	7·7684	25·169	·2703	7620
2½	7·7660	24·569	·2658	7314
3	7·7666	25·031	·2689	7538

The second series of experiments was upon compression, yielding the following results:—

Compressive Strain.

Approximate thickness of plate in inches.	Mean ultimate pressure per square inch in tons.	Mean ultimate compression per unit of length.
1½	90·967	·513
2	90·967	·518
2½	90·967	·510
3	90·967	·511

The third and most important series of experiments was that on punching and shearing. It was supposed that the resistance of armour-plates to the impact of shot was analogous to that produced by statical pressure. Under this supposition it was thought desirable to institute a series of experiments to ascertain to what extent the law was applicable to the resistance of iron plates by punching, in order to apply it to the more important experiments on impact. These experiments—made with a flat-ended punch—fully established the formula that the resistance of armour-plates to a force tending to perforate them varies as the diameter of the punch multiplied by the thickness of the plate or the depth of penetration.

Another series of experiments with a round-ended punch was instituted by the Iron-plate Committee for the purpose of comparing the resistance of armour-plates to flat-ended and round-ended projectiles, and tables were given to show that the statical resistance to punching was about the same whether the punch was round-ended or flat-ended. The following is the general table of comparison:—

Description of gun.	Weight of shot in lb.	Charge of powder in lbs.	Velocity in feet per second.	Semi-diameter of shot.	Maximum thickness of perforation. By experiment.	Maximum thickness of perforation. By formula.	Error of formula.
Armstrong 6-pr. . .	6·25	0·75	1,141	1·22	1·286	1·406	+ 1/11
,, 12 ,, . .	11·56	1·50	1,155	1·46	1·803	1·769	− 1/53
,, 25 ,, . .	24·81	3·13	1,169	1·84	2·350	2·337	− 1/180
,, 40 ,, .	40·00	5·00	1,166	2·35	2·820	2·663	− 1/18
,, 100 ,, . .	110·00	14·00	1,175	3·45		3·613	
Smooth-bore 68-pr. .	66·25	16·00	1,557	3·96		3·470	

In the discussion which followed, Mr. Scott Russell pointed out that, in regard to the effect of spherical shot on plates, if they took a plate the thickness of which was equal to the semi-diameter of the shot, the strength of the plate was quite equal to the resistance of the shot. This was true of the smaller diametrical shot, but the thickness of the plate had to be increased for the larger shot.

(50.) **The Elements of Iron Construction.**—*Section A: Wrought-iron Beam Work.*—In presenting to the student a few "notes" on iron construction, we shall commence with what are called "built" beams, that is, those made up of a certain number and kind, of distinct parts, and hence so named in contradistinction to those beams which are now so largely used, which are rolled out by machinery in the solid form. These latter being of the simplest kind, might, in accordance with a more systematic treatment of the subject of iron construction, have been taken up first; but although built beams belong, as is apparent, to the more complex and advanced kinds of iron construction, we prefer to take them up first, inasmuch as they permit of our giving what may be called their elementary forms or their component parts. Wrought-iron built beams are made up of flat plates of various superficial dimensions, these being kept together and strengthened by smaller parts, known as "rivets," "pins," "screw bolts and nuts," "fishing plates," "T" irons, "L" irons, and "angle" irons. In fig. 202 we give a section

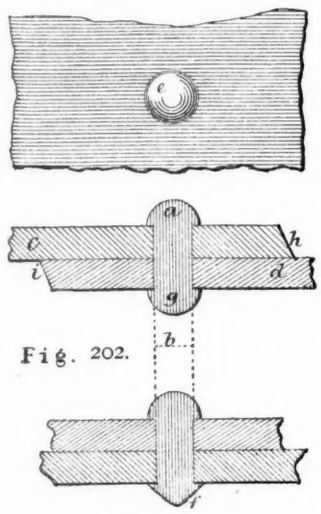


Fig. 202.

showing the usual methods of riveting. A rivet in its original form is simply a piece of rod-iron having a forged head *a*, and what may be called a shank or end *b*, of the original dimension of the rod, and with a straight end, as shown by the dotted lines. The two plates to be joined, as *c d*, have a hole *e*, either punched or drilled—on the relative merits of punched and drilled holes for riveted work much has been written, and many experiments in connection therewith have been made, to which we may hereafter refer—the rivet, previously heated in a small forge fire to a red heat, is seized by a boy with a pair of

pincers or smith's tongs, and the end *b* passed into the hole *e*. While one man presses upon the end *a* with an iron tool, another man, with a hammer, and by means of a succession of rapid and well-directed strokes, hammers the end *b* into the shape, as shown in full line at *f*. The hammered end may be, and in the majority of instances is, left of the tapering form shown at *f*, or by means of a tool with a hollow depression at its end, called a "snap," is finished off so as to be rounded similar to the end *a* of the rivet. In machine riveting both ends of the rivet are generally left rounded as at *a* and *g*. In boiler-plate riveting the lines of junction of the two plates are put closely in contact by means of a caulking tool, the joints then assuming somewhat of the appearance as shown at *h* and *i*. The position which rivets assume to one another in long lengths of plate work are of different kinds. In fig. 203 we illustrate what is called "single

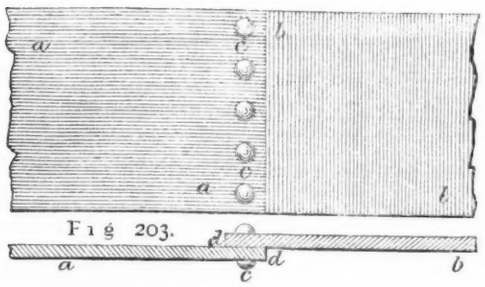


Fig 203.

riveted" plates, the plates *a b* being joined by a single line of rivets *c c*. In fig. 204 we illustrate "double riveting," in which

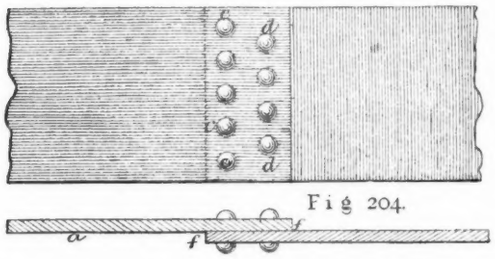


Fig 204.

the plates *a b* are joined by two lines or rows of rivets, *c d*; but these are not placed parallel to one another, but so arranged as to form a series of triangles, as *c d e*. This form of riveting is much stronger than the single riveting. In fig. 205 we illustrate what is called "chain riveting," used in large beams for bridge work, &c. In joining two lengths of these plates by the methods as illustrated in figs. 203, 204, and 205, the student will perceive that in the lap of the two plates a break

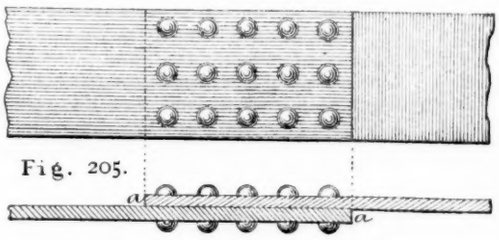


Fig. 205.

as at *d d*, in fig. 203, *f f* fig. 204, and *a* in fig. 205, is formed; and this is, of course, repeated on both sides of the junctions. To avoid this, another form of joining plates is adopted in which the edges of the two plates are brought close up together, forming what is called a "butt joint," and the two plates are secured together by a plate at one side riveted to the two plates; the joining plate is generally called a "fishing plate," or covering plate, as in fig. 206, in which *a* is the front or flat-face view, *b* the edge,

Fig. 206.

or side, and *c* the end view. In fig. 207 we illustrate two plates, *a* and *b*, joined with a third or fishing plate, *c c*, at the back, the rows of rivets being as at *d d*, and showing the same on both sides; *e* is the "butt joint." In fig. 208, a method of joining two plates *a* and *b*, with a butt joint *c*, and with two fishing plates, *e* and *d*, one at front and one at back, is illustrated. In fig. 209, a method of joining three thicknesses of plates *a a'*, *b b'*, *c c'*, with a single fish plate *d* at the back, is illustrated. If each thickness of plate is made up of more than one plate, that is, if the riveted structure is of greater length than the full breadth of the manufactured plate, the plates join together with "butt joints," as at *e f* and *g* in fig. 209. It will be observed that these "butt joints" "break joint," as it is technically termed, that is, that all the joints are

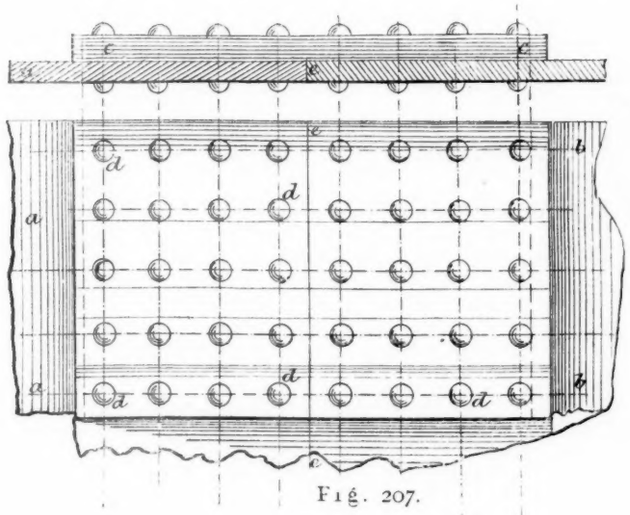


Fig. 207.

not in line as at *a b* and *c* in fig. 210, but that the joint, as at *f* in fig. 216, strikes against the solid parts of the plate above as *a*, and the solid part of the plate below as *b*. It will also be observed that the butt joints, as *e f* and *g* in fig. 209, preserve a regular gradation in their distance from each other. This is obtained by dividing the length of the fishing plate, as *d d*, into a certain number of equal parts, this depending upon the number or the thicknesses of the plates to be joined, as *a a'*, *b b'*, *c c'*, the

divisions in *d d* being always one more than the number of the plates. Thus in the drawing there are three thicknesses of plates to be joined, so that the length of the fishing plate *d d* is to be divided into four equal parts ; the joint *g* is at the first of these, the joint *f* at the second ; but in the second row of plates the joint *e* being not at the third division, but in the third row of plates. Rivets, as already stated, are of two kinds, "snapped" or "cupped," and "hammered" or "hand-wrought." The former, illustrated at *a g*, fig. 202, is so called from the head of the rivet being formed by means of a tool with a hollow, and called generally a "snap" or "cup;" these rivets are more quickly formed and finished than the hand-wrought ones, which are hammered till they assume the shape of the cone as at *f*, fig. 202 ; but they are not so strong as the hand-wrought rivets. The method in which the rivets are disposed in the junction of two plates exercises, as above hinted at, a very marked influence upon the strength of the junction. This discovery we owe to the experiments of Sir William Fairbairn, to whom engineering practice is so much indebted in nearly all its departments. Thus, previous to the experiments of this authority—and, indeed, the practice is still by many ironworkers kept up—the only method of riveting plates together was by a single row of rivets, as *a a*, in fig. 203. In experimenting upon plates thus riveted together, the plates were found, under the strain put upon them, to curl upwards at the edge at each side, producing a diagonal strain upon the plates, tending materially to reduce the strength of the joint. To obviate this, the rivets were arranged so as to form a series of isosceles triangles, as in fig. 204, at *a a*. Experiments with plates thus riveted together showed some very striking results as to their increased strength as compared with plates riveted as in fig. 203 ; and it was shown also that plates joined as in fig. 204 retained their position under strain much better. It is obvious that a plate of wrought iron will be weaker after being joined than before, in consequence of the amount of metal punched or bored out to receive the rivets ; and also, as may be reasonably supposed, by altering the line of strain by the presence of these holes, leaving comparatively small solid spaces of metal between the holes in their line of direction ; and further, and perhaps more markedly, by internal injury done to the fibre of the plate by the strain thrown upon the parts where the holes are punched out. The extent of weakening of the punched plates will of course depend upon the distance between the holes, or their number in the plate. In boilers and other structures requiring to be water-tight, as ships' sides, &c. &c., the number of rivets require to be very close, in order to secure a water-tight joint ; in these, therefore, the weakening effect of the junctions are more marked. The results of experiments upon plates in structures of this kind show the following proportions, taking the strength of the plate in its original condition, before being punched and riveted together, at 100 ; the strength, riveted as in fig. 204, is 68 ; and as in fig. 203, at 46. But considering that in the case of actual practice a considerable accession of strength would be obtained by the greater number of rivets than in the plates on which the experiments were made, from which the proportions above stated were deduced, the following proportions of the strength of the joint, as in fig. 203, known as the "single-riveted joint," and of the "double-riveted joint" in fig. 204, may be taken as fairly correct, and are those which are

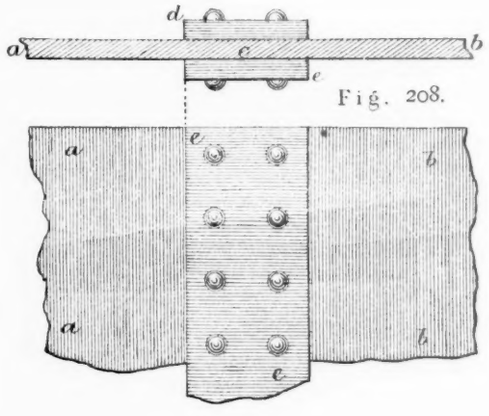


Fig. 208.

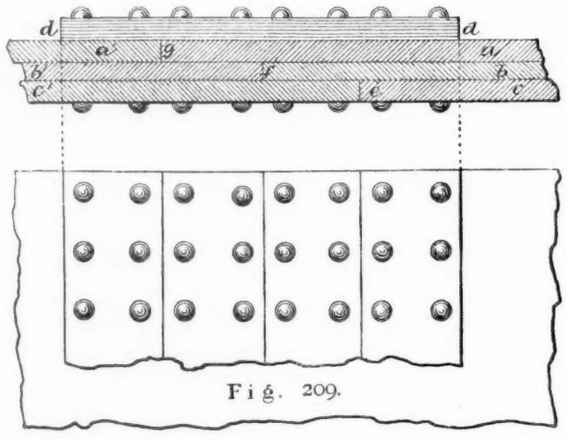
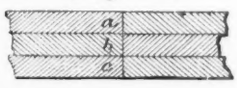


Fig. 209.

now accepted by engineers. Taking the strength of the unpunched or unbored plate at 100, that of the "double-riveted joint," in fig. 204, is 70 ; and that of the "single-riveted joint," in fig. 203, is 56. But in the junction of iron plates, where a water-tight joint is not required, as in bridge work, &c. &c., the system of what is called "chain riveting" is generally adopted ; this is illustrated in fig. 205. This arrangement of the rivets admits of the whole of them being placed in a line with that of the tensile strain thrown upon the plates. Circumstances decide the

Fig. 210.



distances between the rivets, but four inches may be taken as a very generally adopted limit of spacing.

There is no fixed definite rule by which rivets are proportioned, and which is adopted universally, engineers varying in their opinion as to what the proportions should be. Those, however, which are pretty generally adopted are as follows :—For plates under half an inch thick, the diameter of the rivet is twice the thickness ; for plates half an inch thick and above, the diameter of the rivet is one and a-half times the thickness. The length of the rivet left above the plate to allow for "snap" finishing or hand finishing is two and a-half times the diameter of the rivet. In Weale's "Engineers' and Contractors' Pocket Book," a "Table of Riveting Proportions" is given, from which we compile the following : The first figure gives the thickness of the plate, the second the diameter of rivets, the third the length from the head, the fourth the distance from centre to centre, the fifth the amount of "lap" for single-riveted joints—$\frac{3}{16}$", ·38, 88, 1·25, 1·25 ; $\frac{4}{16}$", ·50, 1·13, 1·50, 1·50 ; $\frac{5}{16}$", ·63, 1·38, 1·63, 1·88 ; $\frac{6}{16}$", ·75, 1·63, 1·75, 2·00 ; $\frac{8}{16}$", ·81, 2·25, 2·00, 2·25 ; $\frac{10}{16}$", ·94, 2·75, 2·50, 2·75 ; $\frac{12}{16}$", 1·13, 3·25, 3·00, 3·25. The amount of "lap" for "double-riveted" joints is found by adding "two-thirds of the depth of the single-riveted joint."

The strength of built beams, in which wrought-iron plates are used, will obviously depend upon the accuracy with which "riveting" is performed. The term here includes not merely the actual formation of the rivet by snapping, or by hand-working, or by *machine*, but the placing of the plates together, and the accuracy with which the rivet-holes are spaced and drilled or punched. This accuracy is a point of still greater importance to be aimed at when there are several plates placed together, as in the top or bottom flanges of box or plate girders ; for it is obvious that if the holes do not coincide in all the plates, undue strain will be thrown upon the plates. The difficulty found in practice of getting the rivet holes so accurately adjusted that the rivets will go fair in, is such that "drifting," as it is called, is resorted to in a great many instances—the operation having for aim the bringing in of the rivet holes into the straight as near as possible. "Drifting" being what may be called a "brute force" method of overcoming the difficulty, brought about in nine cases out of ten by careless or indifferent marking out and punching or drilling the holes at first, should not be allowed ; but such rivet-holes as do not exactly correspond, or are out of line, should be brought right by the use of the "rymer," by which the irregularities of

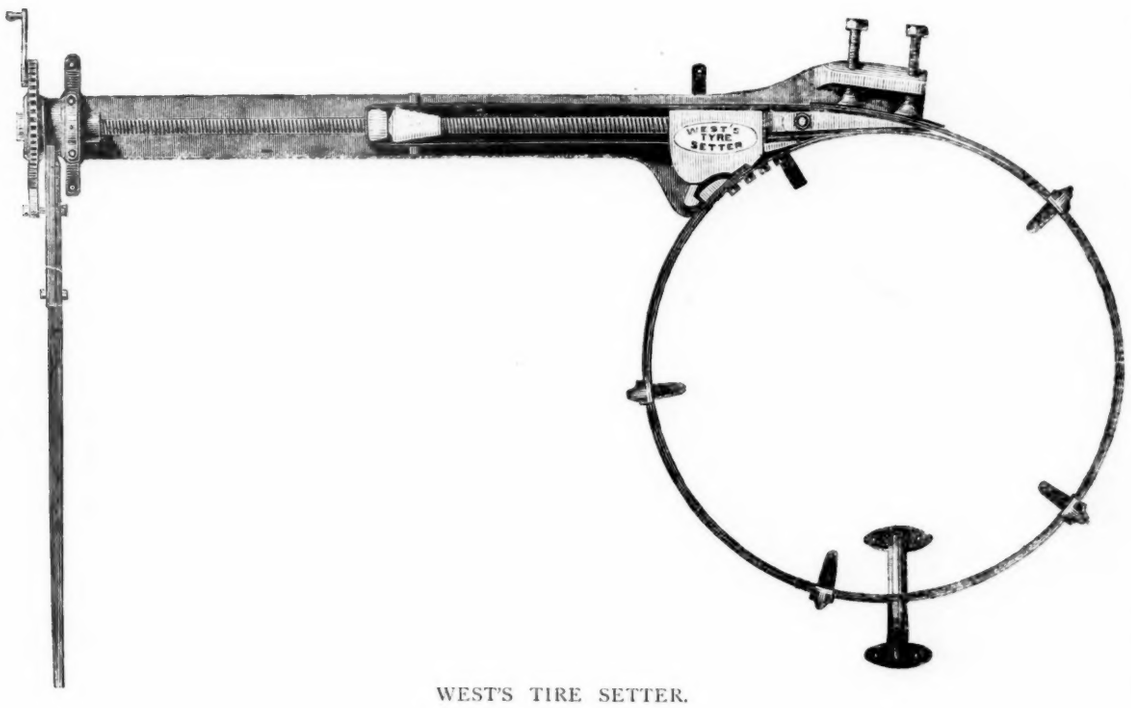
metal in the line of the rivet holes will be pared off. To lessen the difficulty of obtaining accurate adjustment of rivet holes, the thickness of flanges or top or bottom plates of "built beams" should not exceed four inches; if the required sectional area to obtain the necessary strength in the beam is not given by this thickness, the breadth of the flange should be increased in the desired proportion. The rivet holes should be spaced out by "templates," so as to insure accuracy in the meeting or coincidence of the holes in the various plates when put together *in situ;* and the edges of the plates butting against each other should be placed so as to insure fair joints. In no case, where good work is required, should the edges and ends be left rough and uneven where they are to butt against each other. It is scarcely necessary to say that, in order to reduce the number of riveted joints, the plates which make up built beams should be as long as possible.

A great deal has been said as to the relative merits of punching and drilling; and of this we may only remark, that drilling, beyond doubt, gives the best results, and, in addition to greater accuracy in the adjustment of the corresponding holes in different plates, it avoids the injury done to the fibre of the plates by punching. Any one has only to thoroughly examine drilled and punched plates to be convinced of the mechanical accuracy of the drilled plates. It is, however, a question of paying and not paying, drilling being more expensive than punching. For small work, where thin plates are used, punching will be found to be, and is found practically to be, the best. If, however, where punching is decided upon, the rivet holes are accurately spaced out, and the adjustment of the plates be carefully looked to, the punching and the riveting honestly done, good work may be fairly expected. The standard of good work is accurately formed rivet holes, all the holes in the different plates coinciding with each other; the rivets filling up closely the interior of the holes, and the sectional area of the rivets equal to the sectional area of the plate, measured in a direction at right angles to the tensile strain exercised upon the plate—in other words, at right angles to the line of rivet holes; and finally, well made rivets of the best iron, put in red-hot, and hammered tight in. In the succeeding note we shall give illustrations of other methods of joining plates in which "angle iron," "T iron," and "L iron" are used.

WEST'S MACHINE FOR SETTING TIRES.

MR. WEST, an American gentleman, has invented a most useful and ingenious machine for setting tires on wheels. The illustrations show very clearly the general arrangement of the contrivance, which is simple, expeditious, and effectual in its action. Our readers are aware that the present mode of setting the tires on wheels is to weld the tire or otherwise form it a trifle smaller than the wheel whose rim it is to embrace, then to expand the iron hoop by heating and to drop it over the wheel, immediately afterwards cooling the tire by means of water thrown over it. As the hoop cools it shrinks and binds tightly on the wheel. The evils of this process are that it occupies much time, causes some waste of fuel, and burns or scorches wood wheels, while the subsequent watering soaks the pores of the wood with the steam generated by the heat of the tire; and besides all this, it is difficult, particularly with iron wheels, to fit and shrink the tire to such a degree of tension as will at once strengthen the wheel and yet put no undue tensional strain upon the tire.

The apparatus will be seen to consist of a steel or wrought-iron hoop formed somewhat like a colossal watch-spring of four or more coils; this is secured to a frame, to which is fitted a screw. To the outer end of the screw is attached a socket to receive a long lever handle, or else, as is done in the larger machines, gearing can be fitted so as to work the apparatus as a power-machine. The compressor hoop, as it may be termed, is supported by suitable brackets, and steps or projections sustain the wheel and hoop while within the compressor. The action of the machine is this: The wheel to be shod,—as the process is sometimes termed,—is placed within the compressor; the tire, which just loosely fits the rim, is put in its place, the screw is then actuated and draws the one end of the compressor, which tightens on the tire, and this is forcibly compressed, so forcibly indeed as to upset the whole metal of the tire, until it binds the wheel to any such degree of compression of the wheel as may be considered suitable. As this compression is

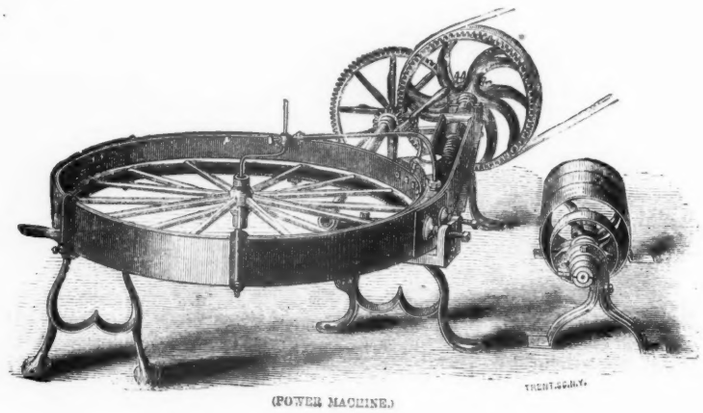


WEST'S TIRE SETTER.

simply a matter depending on the strength of the machine and on the power applied, it is evident that the wheel could be crushed if necessary. Here then is a machine that consumes scarce any time, no fuel, does no injury to the wheel, and will tighten old and loose tires without need for removing, cutting, or re-welding them. Besides this, the material of the tire itself being thus upset, is rendered denser and more durable.

The machine has been introduced into this country by Messrs. Churchill, the well-known American firm, of 28, Wilson Street, Finsbury. It is made in sizes to suit different sizes and kinds of work. No. 1, the smallest size, is constructed for wheels of from 3 feet to 4 feet 2 inches in diameter, with iron tires $\frac{3}{4}$ of an inch thick by $1\frac{1}{8}$ wide, or steel tires 1 inch × $\frac{1}{4}$ inch. The larger sizes suit wheels 3 feet 5 inches to 4 feet 7 inches, with tires of proportionally heavy sections. Each machine will hoop wheels not varying more than 14 inches in diameter. Messrs. Churchill compute that the saving of cost of this mode of shoeing new wheels as compared with the common way equals some 30 per cent., the saving with old wheels and tires much exceeding this amount. Another great advantage derivable from the use of this machine besides those enumerated above, is that with old tires and wheels there is no need for plugging the old rivet holes in the felloes and boring others elsewhere to fit the altered tire.

Messrs. Churchill are exhibiting one of these machines at the Vienna Exhibition, besides one of the Silsby Manufacturing Company's rotary steam fire engines, in which both the steam-engine and the pumps are rotary; and they also exhibit various little matters in the way of small tools, such as hand-drills, vices, chucks, *et hoc genus omne*, things for which our cousins over the water have been long celebrated.



(POWER MACHINE.)

THE INDUSTRIAL DEPARTMENT OF THE LONDON INTERNATIONAL EXHIBITION, 1873.

Report on Classes VIII. IX. XII. XIII. and XIV.

[*By our Special Reporters.*]

THE first section of Class XII. comprises agricultural products and manures. Amongst the artificial manures at present employed in agriculture, superphosphate, forming as it does in most cases the basis of all special manures, undoubtedly stands first. The great extent to which the consumption and manufacture of superphosphates has increased of late years furnishes abundant proof, if such were needed, of its immense importance in connection with the root cultivation of this country.

This valuable fertilizer is prepared by dissolving various phosphatic materials, such as bones, bone ash, coprolites, French phosphate, &c., by means of sulphuric acid, from which there results a soluble combination of phosphoric acid, termed by chemists biphosphate of lime.

Amongst the exhibitors we notice Messrs. E. Packard and Co. of Ipswich, whose works are reckoned among the largest of the kind. The raw materials used at their factory are chiefly coprolites from the Cambridge district and from Suffolk, and French phosphate of lime, which comes from the mines lately opened by the firm in the neighbourhood of Bordeaux. It contains from 75 to 83 per cent. of phosphate, and is found in narrow veins which run nearly vertically from 10 to 100 feet below the surface in the limestone rock. It is probably an aqueous deposit, containing no fossils whatever.

We are enabled through the courtesy of Mr. E. Packard, who conducted us over the interesting works, to give a brief description of the operations required for transforming the native insoluble phosphates into the soluble form.

The process begins by throwing the raw material into the mouth of a hopper which carries it to a pair of rollers which roughly crush it; on leaving these it is caught in the buckets of an elevator and conveyed to the floor above, the buckets emptying their contents into the hopper of a grinding mill, from which it comes in a smaller form, but only to undergo a further crushing preparatory to the final grinding under one or other of the thirteen pairs of stones, which reduce from 400 to 500 tons of hard stones to an impalpable powder in the course of a week. These mills deliver the coprolite dust into bags holding two hundredweight each, which are accurately weighed before they are wheeled from the mill to the mixing-house, which we next visit, passing on our way the blasting-furnace in which the sulphate of lead, produced by the action of the sulphuric acid on the chambers, is melted. The mixing machines, though highly important agents in the manufacture, are very simple affairs, and consist of a wooden frame lined with lead, in which a shaft with arms revolves so as thoroughly to mix together the phosphate and the acid. The bags of phosphatic powder as they arrive from the mill are set down in rows. Two of these (a mixing consisting of four hundredweight of coprolite to a certain proportion of sulphuric acid) are emptied into a truck which is drawn up an inclined plane and its contents tipped into the hopper of the mixer. The sulphuric acid tank is by the side of the mixer, and is in communication with the acid chambers. It is provided with a glass gauge, by which the workman in charge measures the dose he is about to administer to the phosphate in the mixer; he draws into his tank the requisite quantity, and the instant the truck has tipped its contents into the mixer admits the acid, the agitators thoroughly stir up the two materials for about two minutes or two minutes and a-half, by which time they have become thoroughly incorporated, and the phosphoric acid has been set free by the action of sulphuric acid rendering the phosphate of lime soluble—the object of the whole of the operations. The mixture is now in a semi-fluid state, its consistency being about that of hasty-pudding, and is suffered to run into one or other of the so-called "dens," in which it cools and hardens. Meantime, during the two minutes the mixer is at work, the action of the gearing which drives the carriage has been reversed, the truck has run down the inclined plane, received a fresh load, and been hauled up again, a fresh dose of sulphuric acid has been admitted to the tank, and as soon as one lot of stuff is let out of the mixer another takes its place, and so the operation goes on. It should be observed that there is no need at these works for diluting the acid before it is introduced to the phosphate, for the oil of vitriol being manufactured on the premises, the strength of the acid in the chambers is regulated with exactness according to the particular manure which is to be made; and as the number of chambers is large—seventeen—the acid of the particular strength required for every description of manure can be kept on hand. There are three of these

mixing machines, and by them from 800 to 850 tons can be turned out in a week. In the manufacture fumes of hydrofluoric acid and fluoride of silicium are given off, which if allowed to go into the atmosphere would be injurious to both animal and vegetable life, and consequently care is taken to collect them at the mixing machine, in connection with which is a large fan driven at a tremendous speed, and this fan drives the noxious fumes along a flue between 400 and 500 feet in length ending in a chimney shaft. During their progress along the flue, through which a stream of water runs, the fumes condense, and what is discharged from the chimney is no longer hurtful. By this condensation very pure silica is obtained, but not in sufficiently large quantities to pay for collection.

The superphosphate thus obtained has the following composition:—

Moisture	16·06
*Organic matter and water of combination	7·11
Biphosphate of lime	17·94
Equal to bone-earth rendered soluble	(27·99)
Insoluble phosphates	3·81
Sulphate of lime (anhydrous)	49·21
Alkaline salts and magnesia	1·64
Insoluble siliceous matter	4·23
	100·00
*Containing nitrogen	·23
Equal to ammonia	·28

In a more concentrated form it is thus constituted:—

Moisture	19·07
Sand	1·90
Biphosphate of lime	35·08
Equal to soluble phosphates	(41·82)
Insoluble phosphate	3·04
Oxides of iron and alumina	1·05
Sulphate of lime, &c.	38·98
*Organic matters and alkaline salts	0·88
	100·00
*Containing nitrogen	0·25
Equal to ammonia	0·25

Compared with dissolved bones, they appear richer in soluble phosphate. Manures of dissolved bones contain in 100:—

Water, expelled at 212°	13·80
Sand	4·00
Bone phosphate of lime, not made soluble	9·80
Biphosphate of lime	16·23
Alkaline and magnesian salts	3·60
Sulphate of lime	35·68
Organic matter, salts of ammonia, and combined water	16·89
	100·00
Ammonia 0·816	
Equal to phosphate of lime made soluble	25·40
Phosphate of lime not already soluble, but will become so in the soil	9·80
Total amount of available phosphates	35·20

A peculiar manure, rich in ammonia, is produced from the liquid obtained from gas works. We give the composition of the samples analyzed by Dr. Voelcker, chemist to the Royal Agricultural Society of England.

Patent ammoniacal phosphate:—

	No. 1.	No. 2.
Moisture	2·53	3·47
Salts of ammonia and combined water	47·70	67·57
Phosphate of ammonia, soluble in water	44·23	24·46
[Equal to tribasic lime phosphate rendered soluble	96·55	53·39]
Insoluble phosphate	2·49	2·76
Lime and magnesia sulphates, &c.	2·46	1·01
Insoluble siliceous matter	0·59	0·73
	100·00	100·00
Nitrogen	12·03	15·75
Ammonia equivalent to above nitrogen	14·60	19·12

The next important exhibitor of phosphatic manures is Alex. Jaille, of Agen (France). The factory of this firm turns out manures specially rich in nitrogen derived from horn, hair, blood, and other animal offal, and mixed with soluble phosphates prepared from native phosphates.

The animal substances are treated in closed cylinders with steam under a pressure of from 10 to 15 atmospheres, through which process they become partially liquefied; the pulp thus obtained is dried and mixed in with phosphates, potash salts, &c.

The blood employed is obtained from the slaughter-houses of Agen, Bordeaux, and Montauban. Through the addition of some common salt or protosulphate of iron, it is preserved for a long time from putrefaction.

In mixing the blood with the dry powder of the disintegrated bones, &c., the serum (the fluid part) is permitted to run off, is collected, and used, after another disinfecting treatment, for a second kind of manure.

The first kind, known in the French market as "Guano Agenais No. 1," contains—

7 to 10 per cent. of nitrogen,
15 „ 20 „ „ phosphates,

and large amounts of potash, soda, and other salts. It is chiefly required for the production of grain, tobacco, and roots, and comes in large quantities into the English market. Its price is 25 francs the kilo.

The second kind contains only—

4 to 6 per cent. of nitrogen
and 6 „ 12 „ „ phosphates.

It finds its chief application in the culture of the vine and wood, and the great wine-growing centres of the south of France are its consumers. It costs 15 francs the kilo.

The above-mentioned native phosphates are brought into the soluble state by the same kind of treatment with sulphuric acid that we have described in the sketch on the processes in the Bramford Works near Ipswich.

The annual production of these artificial guanos by the firm of Alexander Jaille amounts to two and a-half million kilos (about 2,500 tons).

The British Seaweed Company of Dalmuir, near Glasgow, exhibit phosphatic manures containing as much as 10 per cent. of potash salts, and a speciality, prepared from seaweed, and designated "Seaweed Charcoal," which is said to have the effect of conveying ammonia to the soil.

When we finally mention tobacco and its mode of manufacture into cigars, &c., we have enumerated all the more remarkable objects that are arranged in the food division.

The XIIIth Class treats of cooking and its science. There are two lectures delivered daily on this most important art, but as these lectures are merely prescriptions for the preparation of various dishes without reference to the chemistry of the materials or the physiological functions of the food obtained from them, we must pass them over here and turn our attention exclusively to the various cooking and heating contrivances. It must be understood that in noticing some of the more interesting apparatus, we give, regarding their usefulness and their advantages, the opinions of the exhibitors.

S. Leoni and Co., London, exhibit amongst other varieties of kitchen apparatus a large cooking machine, in which gas is employed as fuel. A machine of this kind has been in use for some time at the London Hospital, where it effected last year a saving of £500. It is calculated that 300 lbs. of meat can by this apparatus be cooked for five pennyworth of fuel.

A neat-looking construction, termed the "Family Kitchener," is specially recommended to small families. The following statistics of its capability speak greatly in its favour:—

Breakfast for five Adults and three Children.

2 pints of coffee. 1 pint of tea.
½ lb. bacon.
½ lb. oatmeal for porridge.
6 rounds of toast.

Time: 20 minutes.

Consumption of gas: 12 ft. (Less than 3 farthings.)

Dinner for twelve Adults and three Children.

6 lbs. leg of lamb. (Loss 1¼ lb.)
4 lbs. sirloin of beef. (Loss 10 oz.)
5 lbs. potatoes.
6 large cauliflowers.
2 large fruit pies.

Time: 1½ hour.

Consumption of gas: 48 feet. (2¼*d.*)

Benham and Sons, London, exhibit under the designation of "Ventilating Kitchener," ranges of different sizes, but all of very elegant appearance. The smallest is 3 ft. wide, has a wrought-iron roaster on one side of the fire, with movable shelves, double dripping-pan and meat-stand, thoroughly ventilated by means of air-tubes and valves (by closing which the roaster becomes an excellent oven); strong wrought-iron side boiler on the other side of the fire, with steam-pipe and brass tap; gridiron for broiling; ash-pan, hook, key, and raker; dampers, register-door, &c. The top consists of a hot-plate, on which boiling, stewing, &c. may be done without injuring and soiling the vessels in use, and which may also be used as an ironing stove. Its price is £11.

The largest is 12 ft. wide, consists of two strong wrought-iron roasters, each fitted with ventilating tube and valve, moveable shelves; double dripping pans and meat stand; two strong hot closets, or pastry ovens, each fitted with valve and moveable shelves; strong framed hot-plate, extending the whole length of the apparatus, for boiling, frying, stewing, &c. without injuring or soiling the vessels in use; moveable panels over the fire, fitted with gridiron for broiling, a strong wrought-iron boiler, capable of heating water for baths, bedrooms, or nurseries;—or of supplying steam for steam-closet and steam-kettles, fitted with inlet and outlet pipes, waste-steam pipe and draw-off tap, fire quarries, dampers, register-doors, hook, key, and raker. It costs £69 10*s*.

Billing and Co., London, show a "Reflector" gas-cooking stove, in which economical cooking is obtained by utilizing every particle of heat derived from the gas.

Departing from the old system of gas-cooking, which was open to many grave objections, the gas-burner is placed above the joint and not under; over this burner is fixed a radiating metal plate to reflect the heat; the same burner being above the joint and beneath the oven answers both for the purpose of roasting and baking at the same time. By another simple contrivance of surrounding the oven with a case or jacket, the heat is thereby increased, the combustion is rendered complete, and also serves another important purpose in causing a regular distribution of heat all over the oven. The most limited experience proves that in all the stoves now in use, the oven is always hottest in that part nearest to the fire, consequently it is a common occurrence for a joint in an ordinary oven to be raw in one part and burnt in another. This is prevented by the hot air surrounding the oven. The stoves are so arranged that a family dinner can be cooked without the aid of any other appliance. The various processes of roasting, baking, boiling, grilling or toasting, can all be carried on, and each process can be regulated to the greatest nicety by the adjustments with which each stove is fitted.

These stoves have been submitted to every possible test, and can be therefore confidently recommended as doing all the work of a kitchen range in a more cleanly, economic, certain, and efficient manner, and no one unless previously informed would have the least idea that the joints roasted by these reflecting gas-stoves were not cooked before a coal fire.

The following are the results obtained by practical experiments of Stove No. 135:—A joint weighing 9 lbs., a large family pie, a couple of ducks, two sorts of vegetables, fish and soup were all cooked at one time in the space of two hours, consuming about 40 ft. of gas, costing from 1½*d*. to 2½*d*. according to the price of gas.

The same firm exhibits a small gas stove, called the "Cheerful," which is more especially adapted for a study or an office-chamber. The lower part of the stove is fitted with bright, polished copper, which reflects the lights burning in the upper portion, and thus imparts a very cheerful look to the apartment in which it stands.

Brown and Green, Luton and London, bring before us their close ranges, which obtained the prize at the Paris Exhibition. The ranges possess the following advantages:—

1st. The upper part of the fire is enclosed with a cast-iron plate instead of the usual door, this plate is made to fall down and form a trivet, affording great facility for boiling when the fire is low. For roasting in front of the fire, this plate has a great advantage over the door, it effectually excludes the usual current of cold air from passing over the fire, thereby economizing heat and saving fuel; as this plate is in immediate contact with the fire, it soon becomes sufficiently red-hot for roasting, and is as effective for that purpose as the open part of the fire below. There are a series of small perforations in the upper part of this plate for the admission of jets of air which partially consume the smoke.

2nd. The fire is of good width for roasting, and proportionately narrow from back to front, thus producing the maximum effect with the smallest consumption of fuel.

3rd. The sliding plate over the fire is much more convenient than covers that lift off.

4th. The kitchener is well ventilated by two conical pipes in addition to the ordinary fall or sliding door.

The castings are strong and clean, and the mountings of the oven doors, &c., are of polished wrought-iron, and the whole are well made. The 5-feet double oven range, with porcelain panels, for style of finish and excellent workmanship is unrivalled, this range is also very complete in all its details. There is one other of somewhat novel construction, the fire is entirely enclosed with cast-iron plates which are heated red-hot for roasting, the ash-pit is also enclosed, and the draught is regulated by a ventilator in the ash-pit door—it is perfectly free from dust and smoke, is adapted for burning coke, very economical, and may be regulated to burn all night without attention and with perfect safety.

The new patent close range with an open chimney of Brown and Green, is constructed on a principle which enables the chimney to be left entirely open, thus preventing the annoyance from close heat and smell of cooking.

Adams and Son, London, exhibit Captain Warren's Patent Cooking Apparatus. The process carried out in this apparatus consists in cooking without the viands coming in contact with water or steam; the meat kept from water entirely is cooked in an inner cylinder, the outer one containing the water being kept at the boiling point. The food thus prepared is cooked in its own vapour, and none of its nutritious properties wasted. The well-known fact that meat cooked by the ordinary methods of roasting or boiling, loses a large portion both in bulk and weight, as well as some very important chemical qualities, is of itself sufficient to stamp with the seal of approbation any invention that avoids these evils. It has been proved, by repeated trials, that meat, fish, and poultry, when cooked in a Warren's pot, retain those nourishing juices which, if cooked in the ordinary method, would have been thrown off in vapour, but by this mode become condensed and are returned in moisture at a temperature sufficient to cook in the most perfect manner. To the poor as well as the rich, this invention will therefore prove a great boon.

The time required for the cooking of different meats is seen from the following table:—

	H.	M.
A leg of mutton, 10 lbs.	3	0
Beef, 10 lbs.	3	30
Goose	2	30
Turkey	3	0
Ham, 12 lbs.	6	0
Hare	2	0
Rabbit	1	30

Salt beef requires one-third longer than fresh, and to be cooked with water in the inner vessel sufficient to cover it. The liquor in which it has been boiled will make superior stock for soup.

The attention of the housekeeper is directed to the following particulars, which the patentee considers well worthy of consideration:—

1. It saves waste and trouble, and as the meat absorbs no water by boiling, its true flavour is preserved.
2. Makes the most nourishing soup at a temperature of 210°, which Baron Liebig says should not be exceeded.
3. Renders burning, scorching, overboiling, and smoking impossible.
4. Compared with ordinary cooking, effects a saving of two ounces in the pound, or 12½ per cent.
5. The most delicately flavoured dishes can be made with ease by inexperienced cooks.
6. Meat may be kept hot two hours without spoiling.
7. Meat so prepared is invaluable for invalids and persons of weak digestion, the juices being retained and the fibre made perfectly tender.

It should be borne in mind that, with the same fire, vegetables may be cooked by placing the steamer on at the proper time.

There is said to be a saving of 50 per cent. in fuel in using Captain Warren's apparatus.

S. Flavel, jun., Leamington, shows the kitchen range which had been at the Exhibition of 1851; it is certainly the most magnificent-looking cooking engine among so many other handsome ranges and stoves now at South Kensington.

J. W. Gray, Torquay, claims for his "Devon Tor" range, amongst other excellences, the possession of the most perfect baking oven for bread, pastry, &c.

Hassall and Singleton, Birmingham, exhibit Wright's patent "Lichfield" cooking range, which can, according to desire, be converted into a close range or an open grate. They are therefore well suited for small cottages and the like dwellings.

The "Worcestershire" range of Jones and Rowe, Worcester, has the pastry oven above the meat roaster, thus economizing room and heat. The flues being constructed of iron, require less frequent cleaning, and much greater facility is given for fixing than in most of the ordinary kitchen ranges. A range 6½ ft. wide consists of large meat roaster, pastry oven, wrought-iron boiler holding nine gallons, a hot plate for boiling, stewing, &c. A small joint can be roasted in front of the fire.

Murdoch and Co., London, exhibit a large variety of fanciful patterns of American stoves. That stoves, whether American or otherwise, are in point of saving of fuel decidedly superior to the usual open grate fire, is a well established fact, but, alas, too much ignored yet by those classes of the public which stand mostly in need of knowing it.

T. Nock, Birmingham, manufacture gas cooking stoves with atmospheric burners, and fire-clay reflectors. The mixing of atmospheric air with the gas causes a complete combustion, and thus prevents the formation of smoke.

The same firm exhibits Currall and Bennett's "Eclipse" range, which combines the advantages of the Leamington range with the cheerful appearance and economy of the open fire-grate. Two objections are generally made to the Leamington and other ranges of that class. The first is, that being always closed the consumption of fuel is very great when not being used for cooking; and the second, that a large amount of room in the ovens is wasted in consequence of the tops of the ovens getting over-heated by the fire passing directly over them. In this range the first objection is remedied by the ease with which it can be converted from a close to an open fire when the ovens are not in use; and the second, by the fire being made to pass under the bottoms of the ovens first, and over the tops afterwards, which ensures an even temperature top and bottom.

A decided novelty is the "Vapour" stove of the Hydrocarbon Heating and Lighting Company. The stove may be described as a gas stove which makes its own gas from a liquid hydrocarbon, known as benzoline, a product of distillation of petroleum. The liquid is contained in a small cistern, connected with the stove, and the cistern may be placed either inside or outside the building. The vapour stove is safe and sure in its action, and requires no more care or attention than an ordinary coal gas stove. To the small householder it is invaluable, but its application is unlimited, and it may be used advantageously in hotels and restaurants, or for any purpose where a uniform heat is required.

J. Wright and Co., Birmingham, exhibit kitchen ranges, stoves, &c., in which the fuel employed is gas, the use of which, in preference to coal or coke, they very warmly advocate. Among the advantages claimed for the airy fuel are: readiness for application, facility of regulation, perfect cleanliness, and—at the present moment—cheapness.

In taking up Class IX., which includes steel and mainly its application to cutlery, we confess our inability to do justice to this all-important subject, were we to attempt a detailed review of all the objects and their mode of manufacture. We shall therefore concentrate our attention upon what we consider to be the most remarkable of recent inventions in the manufacture of steel and iron. Under No. 3,774 Dr. Siemens exhibits a model of his latest improved furnace for the production of iron and steel, and we will, in order to give a lucid sketch of the new process (of which a short notice has appeared already in this magazine), quote the lecture which the inventor delivered a few weeks ago before the Chemical Society.

Some time ago he had described a method of producing cast-steel upon the open hearth of a regenerative gas furnace by the dissolution of scrap-iron or of ores in a more or less reduced state in a bath of intensely heated pig metal. These processes have now received very considerable practical development at the works of the Landore-Siemens Steel Company, of Messrs. Vickers and Company of Sheffield, and at several other works. Two processes are employed at these works, the Siemens-Martin process, which consists in dissolving scrap metal or steel in a bath of pig metal to which spiegeleisen is finally added, and the ore-reducing process, in which pig-metal and ore in a more or less reduced condition is employed.

The process chiefly employed at the Landore works consists of introducing on the bed of an intensely heated regenerative gas-furnace, about 6 tons of pig metal, which may be of No. 3 or No. 4 hæmatite pig. When a fluid bath has been formed, oxide of iron (which should by preference have been melted beforehand with such proportions of lime or other fluxing materials as to form with the silica in the ore and in the pig metal a convenient slag) is added, or natural ores may be used in their raw condition if they contain lime and manganese, as, for example, the African Mokta ore. When about 30 cwt. of this ore have been dissolved (with ebullition) in the metallic bath, it is found that a sample taken from it contains only about 0·1 per cent. of carbon, a point which can easily be detected by the eye of the workmen by a peculiar bright appearance of the sample when chilled in water and broken by the hammer.

In order not to pass beyond this point, samples are taken out from time to time during the latter part of the operation. When the requisite point of decarburization has been reached, the supply of ore must be stopped, and from 8 to 10 per cent. of ferro-manganese or spiegeleisen added to the bath. When this has been well incorporated by stirring, the metal is ready to be tapped into a ladle mounted upon wheels, which is afterwards propelled into the foundry, and discharged either into ingot moulds, to be hammered and rolled, or into dried clay moulds for the production of steel castings.

Considerable difficulty was experienced to find a material to resist the excessive heats necessary for carrying out this process; ordinary Dinas bricks, which are considered the most refractory material in general use, would be rapidly melted, but a brick, specially prepared by crushing pure quartz rock, and mixing it with no more than 2 per cent. of quick lime to give cohesion, answers well. The hearth of the furnace is made of white sand with a small admixture of more fusible fine sand, which mixture sets exceedingly hard at a steel-melting heat, and possesses the advantage of combining into a solid mass with fresh materials introduced between the charges to make up for wear and tear. The hearth and the furnace roof, if of the materials just specified, are very little attacked when the Siemens-Martin process is used, although the heat must be sufficient to maintain wrought iron containing only a trace of carbon in a perfectly fluid condition. If pig metal, and ore (fused together with the necessary amount of flux) is used, the furnace also stands well, but the use of raw ore entails the disadvantage of a more rapid destruction of the furnace; even magnetic oxide of the purest description necessitates the addition of raw lime for the formation of a fusible slag, and the dust arising from the lime and through the decrepitation of the ore causes the silica bricks to melt away rapidly, so that after perhaps two months' usage, the 9-inch arch of the furnace is reduced to the thickness of from 1 to 2 inches. It is evident that silica is chemically speaking an objectionable material to be used in the construction of these furnaces, because it prevents the formation of basic slags, and that a furnace constructed of pure alumina or lime would be preferable. M. Le Chatelier, Inspecteur-Général des Mines, whose valuable labours for the advancement of iron metallurgy are well known, suggested to Dr. Siemens years ago the use of Bauxite (from Baux in France, where it was first discovered), a mineral consisting chiefly of alumina, for making the furnace-bed, but it was not possible to succeed with this, owing to the great contraction of the mass when intensely heated, and non-cohesion with the same material introduced for the purpose of repair. In attempting to construct the sides and roof of the furnace of Bauxite bricks, these were not found to be equal in heat-resisting power to silica bricks, which latter are indeed unobjectionable, except when raw ore and limestone are used.

If good pig metal, such as is used in the Bessemer process, is employed, a metal of high quality is the result, equalling in most respects the steel produced by melting Swedish bars in pots by the old Sheffield process.

There is manifestly an analogy between this and the Bessemer process, both of them being processes of decarburization of pig metal; yet there are very important differences, both as regards the nature of the chemical re-actions and of the metal produced. In the Bessemer process the silicon and carbon are fully oxidized by the action of the blast, whereas sulphur and phosphorus are known to remain unoxidized. Manganese is oxidized in the Bessemer process only to a certain extent, and therefore it is not necessary to add spiegeleisen at the end of the operation, when the pig metal contains a moderate amount of metallic manganese, as is the case in Sweden and in Styria. Notwithstanding the non-oxidation of manganese, from 8 to 10 per cent. of iron is oxidised in the Bessemer process, although iron has naturally less affinity to oxygen than manganese. The oxidation of this amount of iron in the Bessemer converter is in so far a fortunate circumstance, as without it the amount of heat necessary to liquefy the resulting malleable iron could not be produced, and the metal would necessarily set in the converter. In the ore-reducing process above described a totally different result ensues, as is shown by the following experiment.

A manganiferous pig was melted, and ore changed in the usual manner. After the pig was completely melted, it contained the ingredients stated in the first line of the following table, from which it will be seen that silicon and manganese were eliminated first, and then very little change took place in the carbon until the two other constituents were completely removed.

Samples taken.	Contained—		
	Carbon.	Silicon.	Manganese.
When pig was melted . . .	1·90	0·57	1·14
1 hour later	1·8	0·233	0·576
2 hours „	1·7	0·183	0·2
3 „ „	1·65	0·05	0·08
4 „ „	1·6	none.	none.
5 „ „	1·1	Manganese and silicon completely gone.	
6 „ „	0·6		
7 „ „	0·2		

The sulphur and phosphorus are oxidized to a considerable extent; a circumstance which enables us to use pig metal containing a certain small percentage of these admixtures, which are not absolutely objectionable unless they occur in excessive proportions, the quantity admissible of both phosphorus and sulphur being about ·08 per cent.

The decarburizing agent employed being ferric oxide, no cast-iron can possibly be oxidized, and a ton of pig metal with its quota of spiegel containing from 9 to 10 per cent. of foreign substances, yields fully 21 cwt. of steel ingots. In this process the addition of spiegeleisen at the end of the operation is an absolute necessity, however much manganese may have been contained in the pig metal employed, because the manganese is rapidly oxidized, as can be seen from the foregoing table.

The reason of the different reaction in the Bessemer process is, in my opinion, that the silica liberated from the beginning of the operation requires a base for its saturation, and that its great affinity to protoxide of iron determines the oxidation of this metal (free oxygen from the blast being present) in preference to manganese.

A characteristic difference between the two metals, in their fluid condition, is that Bessemer metal on cooling in the moulds sets up a violent ebullition, probably resulting from a reaction between occluded oxygen and carbon, which is counteracted by stoppering the moulds. The ore process metal, if it has been made with care, on the contrary, contains no occluded oxygen, and sinks in the moulds on cooling in the same way as "dead melted" steel does produced by the old Sheffield process.

It has been an open question between metallurgical chemists whether manganese is really required to be present in malleable steel, some maintaining that its beneficial action is confined to the elimination of sulphur during the process of production. Such, however, is not the case, as may be seen from the following extract from Messrs. Hackney and Willis's report:—

"Our observation, based on five years' experience, is that no chemical reaction takes place between the manganese of the spiegeleisen and the other elements of the steel, but that it acts simply as an alloy. With regard to manganese not removing any sulphur in a bath of steel, it is a curious fact that the reverse takes place in a blast furnace. As the percentage of manganese in the pig increases, so does the sulphur decrease; for instance, if to ore and coke, which in the ordinary way will produce a pig containing from 2 per cent. to 3 per cent. of sulphur, manganiferous ore is added so as to put 2 per cent. of manganese into the pig, the sulphur will be reduced to ·05 or ·08 per cent.; but when 3 per cent. of manganese is found in the pig it never contains more than a slight trace of sulphur. We have had occasion lately to analyse several hundreds of samples of pig-iron made under these conditions, and can vouch for the accuracy of this statement, and we think it a fact well worth the attention of ironmasters who are troubled with an excess of sulphur either in their ores or fuel.

"Every one must have noticed the absence of sulphur in all analyses of spiegeleisen, although much of it is made from coke, and most of the ores used contain a considerable quantity of pyrites.

"That the manganese acts by its actual presence, and not by any chemical reaction, is, we think, proved by the fact that, if through any accident or carelessness of the workmen, the charge is left in the furnace for more than twenty minutes after the spiegeleisen is fairly melted, the steel is invariably bad, owing to the oxidation of the manganese; and therefore, if such delay occurs, a small addition of spiegeleisen is made, and no bad results follow."

About the impurities of steel, the same gentlemen report:—

"The presence of sulphur, it is well known, makes steel red-short, and the only question is, how much may it contain without injury? Our experience is, that up to ·08 per cent. will do no harm, provided there is also present 3 per cent. of manganese, and I have even found ·112 per cent. without having any complaint from the hammermen.

"Phosphorus does not appear to affect either the rolling or hammering of steel, even if 2 per cent. is present; but if it exceeds 0·8 per cent., the rails become so cold-short, that they will not stand the severe test to which they are subjected.

"The presence of arsenic and phosphorus increases the hardness of steel at the expense of its toughness.

"The effect of copper is not yet understood; according to Percy, it renders steel red-short to a greater extent even than the same amount of sulphur.

"From the nature of the process, as a rule, very little, if any, silicon is found in Siemens' steel. The carbon and silicon appear to be eliminated equally when manganese is not present; and, as the carbon is generally in excess of the silicon, none remains when the carbon is reduced to 2 per cent. The small amount found in the steel is derived from the spiegeleisen."

At the Landore Works, upwards of 1,000 tons of cast-steel are produced weekly by these processes, and other works, such as Vickers and Company, Krupp, of Essen, &c., are using the same for the production of steel of high quality.

Both in the ore-reducing and in the Siemens-Martin or scrap process, pig metal forms the principal basis, being used either as such, or as puddled iron or Bessemer scrap metal, resulting from the conversion of pig metal by a previous process.

But Dr. Siemens has now succeeded in obtaining iron and steel directly from the ore. True, the idea of such conversion is no novelty, inasmuch as the ancient Indians and Romans produced their iron by a direct process from the ore, and further, the wholesale extraction of metal from the ore is so easy, that it is the prevailing opinion among metallurgists that in any improvement in iron manufacture the pig must be considered as the starting point.

Yet Dr. Siemens proves that upon theoretical grounds the blast-furnace is open to very grave objections, inasmuch as it produces iron combined with nearly all the objectionable substances contained in the materials used, that only expensive fuel, such as coke, can be employed, and that its combustion is necessarily imperfect.

A study of the distribution of temperature in the blast-furnace, shows that the reduction of the metallic oxides to spongy iron is accomplished within the first twenty feet of their descent in the furnace, and at a comparatively low temperature. This upper zone is followed by one where the limestone is decomposed and the carburization of the spongy metal is commenced. Between this second zone and the zone of fusion in the boshes of the furnace a zone of great magnitude intervenes, where apparently no other change is effected than an increase of temperature of the spongy metal, but where in reality a very powerful reducing action is accomplished of substances which had much better not be joined to the iron. It is well known that almost all the phosphorus contained in the ironstone, the limestone, and the coke, is here incorporated with the spongy iron. The silica is reduced to its metallic condition, and, together with sulphur, arsenic, and other bases which may be present, combines with the iron. The final action in the blast furnace consists only in fusing those reduced substances and forming the slags which envelope and protect the fused metal.

Dr. Siemens then shows that, inasmuch as the chief result of combustion in the blast-furnace is carbonic oxide, the origination of which produces only 2,400 heat units per pound of pure coke consumed, whereas a perfect combustion of the same coke would develop 8000 heat units, a great waste of fuel takes place in the blast-furnace. The loss of heat must in the best examples of blast-furnaces be calculated as amounting to fully two-thirds of the heat which the fuel would produce if it were burnt to carbonic acid.

"In a former lecture," continued Dr. Siemens, "I described a plan of reducing iron oxides by feeding them, mixed with carbonaceous materials, into a reverberatory furnace through inverted hoppers of fire-clay, the intention being to effect the reduction of the iron ores into spongy metal during their descent, and the fusion of the spongy metal so produced on the open hearth of the furnace, pig metal being used to facilitate the fusion. It was found, however, that the quantity of heat that had to be transmitted through the sides of the fire-clay hopper was so great that the process of reduction proceeded very slowly, and the hoppers themselves were rapidly destroyed by the intense heat of the furnace. The time necessary for the reduction of the metallic iron in closed chambers of this or any other form which I have tried cannot be effected in less than about thirty-six hours, and that at a great expenditure of fuel for heating the chamber externally.

"This unsatisfactory result directed my thoughts to another method of producing spongy iron by means of a rotative furnace. This furnace consisted of a long cylindrical tube of iron of about eight feet diameter, mounted upon antifriction rollers; the brick lining of it was provided with longitudinal passages for heating currents of air and gas prior to their combustion at the

one extremity of the rotating chamber. The flame produced passed thence to the opposite or chimney end, where a mixture of crushed ore and carbonaceous material was introduced. By the slow rotation of this furnace the mixture advanced continually to the hotter end of the chamber, and was gradually reduced to spongy iron. This dropped through a passage constructed of refractory material on to the hearth of a steel-melting furnace, where a bath of fluid pig metal had been provided. The supply of reduced ore was continued till the carbon in the mixture was reduced to the minimum point before indicated. The rotation was then arrested to prevent further descent of reduced ore; spiegel was added; and the contents of the melting furnace tapped into a ladle and thence into ingots, as before described.

"This rotatory furnace was erected by me at the Landore Works in 1869, and it was so far successful, as the reduction of the ore was accomplished in a comparatively short time. A difficulty, however, presented itself, which led to its immediate abandonment; it was found that the spongy metal produced absorbed sulphur from the heating gases, and was rendered unfit for the production of steel; the spongy iron moreover, upon its introduction into the steel-melting furnace, floated upon the metallic bath without being readily absorbed into it, and was in great part reoxidized and converted into slag by the action of the flame in the furnace.

"These experiments convinced me that the successful application of reduced ores could not be accomplished through their conversion into spongy metal, and fully explained to me the want of success which has attended the previous efforts of Clay, Chenôt, Yates, and others, to produce iron directly from the ore. On the other hand, I had observed that in melting iron ores no sulphur was absorbed from the flame; and it occurred to me that by melting ores mixed with fluxing materials in a furnace so arranged as to accomplish its fusion in a continuous manner, and on a large scale, the fused ore might be acted upon by solid carbonaceous matter, so as to separate the metallic iron in a more compact form, while the earthy constituents of the ore would form a fusible slag with the fluxing material. Experiments proved that this reduction by precipitation of the iron could be accomplished only at an intense heat, exceeding the welding heat of iron, but that the iron so produced was almost chemically pure, although the ores and the fuel used might contain a very considerable percentage of sulphur and phosphorus. The following tables give the analysis of the ores and the iron made from them in this manner, as also the yield of iron obtained from a ton of ore:—

Results of Precipitation Process at Landore.

Ores.	Charge. Total.	Charge. Coal charged in furnace.	Yield.
Mokta ore . . 12 cwt. Scale . . . . 8 „	20 cwt.	6 cwt.	14 cwt.
Mokta ore . . 10 „ Scale . . . . 8 „	18 „	4 „	14 cwt. 2 qrs.
Mokta ore . . 12 „ Scale . . . . 8 „	20 „	6 „	11 „ 2 „
Mokta ore . . 6 „ Scale . . . . 4 „	10 „	2 „	12 „
Mokta ore . . 10 „ Scale . . . . 10 „	20 „	6 „	15 „ 2 „
Mokta ore . . 14 „ Scale . . . . 12 „	26 „	6 „	18 „
Total	114 cwt.	30 „	85 „ 2 „

Results of Rotator.

	Ore.	Lime.	Coal.	Iron.
Vickers, Sheffield	984	48	216	492
„ Birmingham . . .	785	40	176	258

Results of Precipitation Process of Blochairn.

No.	Ores.	lbs.	Charge. Total.	Lime.	Coal.	Yield of Iron.	Analysis of iron Impurities.
1	Purple . . . Red	450 150	600	56	356	137	Sulphur . ·055 per cent. Phosphorus ·114 „ Silicon . ·13 „
2	Purple . . . Red	168 56	224	12	170	165	
3	Melted . . . Coke (powder)	350 210	560	—	—	160	
4	Purple . . . Blackband . .	300 600	900	90	390	210	
5	Blackband . . Clayband . . Purple . . .	600 600 300	1,500	150	400	210	
6	Blackband . . Clayband . . Purple . . .	300 300 300	900	90	145	202	
7	Cleveland . . Purple . . .	900 300	1,200	120	290	268	Sulphur . ·041 per cent. Phosphorus ·150 „ Silicon . ·03 „

Working Results of the Cascade Furnace at Landore.

Charge in Cwt. Mokta Ore.	Roll Scale.	Total.	Coal.	Yield. Puddled Bar. Cwts.	Qrs.
8	8	16	4	7	2
10	8	18	3	15	
6	6	12	3	8	
4	8	12	4	11	
10	8	18	6	13	
6	4	10	2	12	
12	8	20	6	14	
10	8	18	4	14	2
12	8	20	6	11	2
10	10	20	6	15	2
14	12	26	6	18	
102	88	190		140	

"The ore employed was Mokta ore, of the following description:—

Fe_2O_3	79·74	Fe = 60·8
Fe O	6·43	
Mn_3O_4	2·92	
Cd O	·52	
Mg O	·25	
$Si O_2$	4·75	
Loss on ignition	5·11	
	99·7	

32 charges, 14,338 lbs. ore . . } Yield in lbs.
„ „ 5,952 „ coal . . } 8,115 = 56·6
„ „ 768 „ lime . . } per cent.

"The furnace used for carrying out the process of fusion for precipitation consists of a reverberatory gas furnace having two beds formed by the ore itself; on the upper bed a lake of fused ore is formed which can be let off into the lower bed by piercing the intervening bank of unfused ore; the lower bed is divided into two compartments, each provided with a working door, used alternately. The dense carbonaceous material, such as anthracite or hard coke, to be used for the precipitation of the iron in the lower bed, is reduced to a state of powder and mixed with about an equal weight of pulverulent ore. This mixture is spread over the bottom surface of the working bed and the fluid ore is let in upon it. By stirring with a rabble it is transformed into a pasty and foaming mass, which in the course of from forty to fifty minutes is shaped into a metallic ball in a bath of fluid cinder, which may be shingled in the usual manner and formed into bar iron or transferred to the pig-iron bath of a steel-melting furnace, where it readily dissolves. The accomplishment of this process involves, however, a certain degree of manual labour and skill, as, if it be carelessly conducted, the yield of iron will be unsatisfactory; the analysis of the slags shows a variable percentage of iron amounting rarely to less than 15 per cent., but reaching occasionally up to 40 per cent.

"It was evident that if iron and steel were to be produced largely by direct process, that process must be a self-acting or mechanical one, and here my attention again reverted to the rotating furnace above mentioned. If I could succeed in fur-

nishing such a rotating furnace with a lining capable of resisting the high degree of heat requisite for the precipitation of the iron, and at the same time capable of resisting the chemical action, I felt confident that this mode of conducting the process must succeed. My attention here reverted to M. Le Chatelier's former suggestion of the use of Bauxite, which possesses the requisite qualities, if only it can be put into a compact form and rendered sufficiently infusible.

"A series of experiments to form solid lumps by using different binding materials have shown that 3 per cent. of argillaceous clay suffice to bind the Bauxite powder previously calcined. To this mixture about 6 per cent. of plumbago powder is added, which renders the mass practically infusible, because it reduces the peroxide of iron contained in the Bauxite to the metallic state. Instead of plastic clay as the binding agent, waterglass or silicate of soda may be used, which has the advantage of setting into a hard mass at such a comparatively low temperature as not to consume the plumbago in the act of burning the brick. When the lining is completed, the interior of the bricks is preserved against oxidation by fluid cinder, added to bind them together, which prevents contact with the flame. A Bauxite lining of this description resists both the heat and fluid cinder in a very remarkable degree, as I have proved by lining a rotative furnace at my Sample Steel Works at Birmingham, partly with Bauxite and partly with carefully-selected plumbago bricks. After a fortnight's working the brick lining was reduced from six inches to less than half an inch, whereas the Bauxite lining was still five inches thick and perfectly compact. It is also important to observe that the Bauxite, when exposed to extreme heats, is converted into a solid mass of emery, of such intense hardness, that it can hardly be touched by steel tools, and is capable of resisting mechanical action as well as the calorific and chemical actions to which it is exposed. The Bauxite used for this lining was of the following composition :—

Alumina	53·62
Peroxide of iron	42·26
Silica	4·12
	100·00

Other Bauxites were composed as follows :—

FRENCH BAUXITES.

First Group.

—	$Si O_2$	$Al_2 O_3$	$Fe_2 O_3$	$H_2 O$
	1·7	66·2	19·7	12·7
	4·2	54·2	28·7	13·0
	3·7	58·9	25·7	12·4
	3·2	55·9	28·1	12·2
	3·2	60·4	25·1	11·5
	3·9	56·4	22·1	13·5
	3·2	61·2	23·1	11·3
	5·9	58·8	23·1	11·3
	2·8	60·7	25·3	11·8
Average { Raw . . .	3·5	59·2	24·5	12·1
Average { Calcined . .	4·01	67·89	28·09	—

Second Group.

—	$Si O_2$	$Al_2 O_3$	$Fe_2 O_3$	$H_2 O$
	2·4	52·5	29·0	15·9
	2·5	41·8	43·7	13·0
	1·7	25·2	53·5	10·05
	2·1	38·7	50·2	11·8
	1·4	38·7	48·5	12·0
	1·1	39·2	49·3	9·4
	1·0	38·7	48·0	12·5
	1·9	41·2	41·7	15·9
Average { Raw. . . .	1·75	39·5	45·5	12·57
Average { Calcined . .	2·02	45·53	52·45	—

AUSTRIAN BAUXITE. *Wocheinite (Carniola).*

	Raw.	Calcined.
$Al_2 O_3$	64·24	85·88
$Fe_2 O_3$	2·40	3·20
$Si O_2$	6·29	8·40
$Ca O$	·85	1·13
$M_g O$	·38	·50
$S^o O_3$	·20	·26
$P O_4$	·46	·51
$H_2 O$	25·74	—

IRISH BAUXITE.

	Raw.	Calcined.
$Al_2 O_3$	35·0	44·58
$Si O_2$	3·5	4·45
$Ti O_2$	2·0	2·54
$Fe_2 O_3$	38·0	48·40
$H_2 O$	21·5	—

The complete rotary furnace, such as is now in use at Messrs. Vickers and Co.'s, at Sheffield, and at the inventor's Sample Steel Works at Birmingham, consists of a set of four regenerators of the usual construction, with reversing valves and gas producers, which latter are not shown. The rotative chamber is constructed of iron, and rests upon four anti-friction rollers. Wheel-gearing is applied by which either a very slow rotative velocity of from four to five revolutions per hour can be imparted to the chamber, or a more rapid velocity of about 60 to 80 revolutions per hour. The chamber is about 7′ 6″ in diameter, and 9′ 0″ long, and is provided with a Bauxite lining about 7″ thick. A tap-hole is on the working side for discharging the slag into the cave below, where it is received in vessels mounted on wheels. At the two extremities of the cylindrical rotative chamber, with its truncated ends, are large orifices, one of which, on the side of the regenerators, serves for the introduction of the heated gas and air as well as for the exit of the products of combustion, and the other, facing the working platform, is closed by a stationary door hung before it in the usual manner. Although the passage for the introduction of the gases in combustion is separated only by a vertical partition wall from the passage through which the products of combustion are led away, the chamber is heated very perfectly, care only being taken that the gases enter the chamber with a certain velocity, which sends them forward towards the door, and makes them reach the exit passage only after having traversed the rotative chamber to and fro.

This rotative furnace is worked as follows :—

"The ore to be smelted is broken up into fragments not exceeding the size of peas or beans ; to it is added lime or other fluxing material in such a proportion that the gangue contained in the ore and flux combines with only a little protoxide of iron into basic and fluid slag. If the ore is hematite, or contains silica, I prefer to add alumina in the shape of aluminous iron ore ; manganiferous iron ore may also be added with advantage. A charge of say 20 cwt. of ore is put into the furnace when fully heated, while it is slowly revolving. In about forty minutes this charge of ore and fluxing material will have been heated to bright redness, and at this time from 5 cwt. to 6 cwt. of small coal of uniform size (not larger than nuts) are added to the charge, whilst the rotative velocity is increased in order to accelerate the mixture of coal and ore. A rapid re-action is the result : the peroxide of iron, being reduced to magnetic oxide, begins to fuse, and at the same time metallic iron is precipitated by each piece of carbon, while the fluxing materials form a fluid slag with the siliceous gangue of the ore. The slow rotative action is again resorted to, whereby the mass is turned over and over, presenting continually new surfaces to the heated lining and to the flame within the rotator.

"During the time of this reaction, carbonic oxide gas is evolved from the mixture of ore and carbon, and heated air only is introduced from the regenerator to effect its combustion within the rotating chamber. The gas from the gas-producers is entirely, or almost entirely, shut off during this portion of the process. When the reduction of the iron is thus nearly completed, the rotator is stopped in the proper position for tapping off the fluid cinder ; after this the quick speed is imparted to the rotator, whereby the loose masses of iron contained in it are rapidly collected into two or three metallic balls. These are taken out shingled in the usual way of consolidating puddled balls ; the furnace is tapped again, and is ready to receive another charge of ore. The time occupied in working one charge rarely exceeds two hours ; and, supposing that 10 cwt. of metallic iron is got out per charge, the apparatus is capable of turning out at least 5 tons of puddled bar per day. If anthracite or hard coke is available for effecting the reduction of the ore, it should be crushed much finer than when coal or brown coal is used, the idea being that each particle of the reducing agent should be fully consumed during the period of chemical reaction. If wood is used, it has to be charged for the same reason in still larger pieces.

"If it is not intended to make iron, but cast-steel, the balls may be transferred from the rotator to the bath of a steel-melting fur-

nace in their heated condition, and without subjecting them to previous consolidation under a hammer or shingling machine.

"It is feasible, however, to push the operation within the rotator, to the point of obtaining cast-steel. If this is intended, the relative amount of carbonaceous matter is somewhat increased in the first instance, so that the ball, if shingled, would be of the nature of puddled steel, or contain even some carbon mechanically inclosed.

"If, now, after removing the cinder by tapping, from 10 to 15 per cent. of ferro-manganese or spiegeleisen is thrown in, and the heat within the rotator is rapidly raised by urging the influx of heated gas and air from the regenerator, the metallic balls will soon be seen to diminish, and presently a metallic bath only will be found in the furnace, which may be tapped into moulds and hammered and rolled into steel blooms or bars in the usual manner. Experience alone can determine which mode of working will ultimately prove the best; but it is probable, that for the production of cast-steel on a large scale, it will always be more profitable to transfer the metallic balls to a separate melting furnace, a series of rotating furnaces working in concert with a series of steel-melting furnaces, to produce charges of five to six tons of fluid steel.

"In comparing, upon theoretical grounds, this method of producing metallic iron with the operation of the blast-furnace, it will be at once perceived that, whereas in the blast-furnace the products of combustion consist chiefly of carbonic oxide, and issue from the top of the furnace at a temperature exceeding 350° C., the result of combustion in the rotative furnace is carbonic acid, which issues from the regenerative furnace into the chimney at a temperature rarely exceeding 175° C. This proves at once a great possible saving of fuel in favour of the proposed method, and to this saving has to be added the fuel required in converting pig metal into wrought iron by the puddling process.

"It may however be asked, why the rotating furnace should admit of the complete combustion of carbon, whereas in the blast-furnace such complete combustion is, as is well known, not possible, because each atom of carbonic acid formed would immediately split up into two atoms of carbonic oxide, by taking up another equivalent of carbon from the coke present. The following explanation will serve to elucidate this point.

"In the rotative furnace streams of carbonic oxide are set up within the mass under re-action; and this carbonic oxide on reaching the surface meets the current of intensely heated air proceeding from the regenerators, and completes with it perfect combustion within the free space of the chamber. The carbonic acid thus generated comes in no further contact with carbon, consequently it cannot split up, but is drawn away unchanged into the chimney, while the evolved heat is taken up by the sides of the chamber and transmitted by reverberation and conduction to the mixture of ore, fluxes, and coal.

"In this process we have, therefore, to accomplish two things, viz., the deoxidation of the ore, and the fusion of the earthy matter mixed with it. If we take (say) hæmatite ore, consisting of peroxide of iron with 10 per cent. of silica, we shall determine the quantity of carbon necessary for its reduction, from the formula,

$$Fe_2O_3 + 3C,$$

which gives $2Fe + 3CO$;

and according to which the consumption of carbon (taking its atomic weight at 12 and that of iron at 56) amounts to

$$\frac{3 \times 12}{2 \times 56} = \cdot 32 \text{ lbs. per lb. of iron reduced.}$$

"The heat absorbed in this reaction amounts, according to Dr. Debus, to 892 units[1] per lb. of iron produced, but on the other hand the further combustion of ·32 lb. of carbon from the condition of carbonic oxide to carbonic acid, or from CO to CO_2, by means of the free oxygen introduced into the rotative chamber from the regenerator, yields

$$\cdot 32 \times 5600 = 1792 \text{ units of heat,}$$

leaving

$$1792 - 892 = 900 \text{ units}$$

available for heating the materials and for melting the slag.

"The quantity of materials to be heated per lb. of iron produced would amount to—

Ore	1·59
Lime or other fluxing materials . .	·16
Total	1·75

and taking the specific heat of Fe_2O_3 at ·154 as determined by Hermann Kopp, and the temperature to which the materials have to be raised at 1,500° C., the heat required for this purpose would not exceed—

$$1{\cdot}75 \times {\cdot}154 \times 1500 = 403{\cdot}5 \text{ units.}$$

To this consumption would have to be added the latent heat absorbed in liquefying the slag. This would amount to ·32 pound per lb. of iron produced, and, although we have no precise data from which we could ascertain the latent heat absorbed in liquefaction, we can hardly estimate it at more than 400 units per lb., or at $\cdot 32 \times 150 = 88$ units, which, with the above 403·5, makes 451·5 units under the 900 heat-units which are available, proving that ·32 lb. of pure carbon would, theoretically speaking, amply suffice to produce 1 lb. of puddled bar from ordinary hæmatite ore, without counting, however, losses of heat by radiation and from other causes.

"In the production of cast-steel, three operations are essentially involved, viz., the deoxidation of the iron, the fusion of the slags, and the fusion of the metal itself with such proportion of carbon and manganese as is necessary to constitute steel of the temper required.

"The theoretical quantity of fuel required to accomplish these operations would exceed that of making wrought iron by the fusion of heated metal, which may be estimated at, say 1000 units, or at

$$\frac{1000}{8000} = \cdot 125 \text{ lb. of carbon per lb.}$$

of steel produced, which have to be added to the ·32 lb. used in reduction.

"In fine, a ton of iron ought to be producible from hæmatite ore with 6·4 cwt. of carbonaceous matter, or say 8 cwt. of common coal; and a ton of cast steel with 8·91 cwt. of carbon, or say 11 cwt. of coal. In giving these figures, I do not wish to imply that they will ever be completely realized, but I maintain that, in all our operations, we should fix our eyes upon the ultimate result which theory indicates, which, owing to the imperfect means at our command, we shall never completely realize, but which we should constantly endeavour to approach.

"In taking incidental losses by radiation through imperfect combustion and through imperfect absorption of peat into account, we find that the actual consumption exceeds the theoretical limits about three times, or that a ton of iron can practically be produced with a consumption of 14 cwt. of coal, and a ton of cast-steel with 21 cwt. of coal, which consumption represents a great reduction as compared with other methods of production."

Steel made by the above-described process is exhibited under No. 3643 in the West Machinery Galleries. The appearance of the specimens of cold-bent bars evinces a remarkable degree of ductility.

Sir Joseph Whitworth and Co., of Manchester, show samples of steel produced under hydraulic pressure. Allusion to this subject was made in this magazine, vol. i. p. 338.

C. and J. Welden invite attention to specimens of cutlery, formed by the American process of welding steel to cast iron. We suppose the process referred to is that of E. Wheeler, of Philadelphia, U. S., which has been noticed in the "Pr. Mag." 1873, p. 436.

R. Hadfield, of Sheffield, has steel tires welded to metal by a patent process of his on exhibition. The advantages claimed by the inventor for his method are the following: the tyre is perfectly welded to the cast-iron centre or body of the wheel, and cannot be separated therefrom in any way, other than by wear, or turning it off in the lathe; the actual use of all the steel put on it is obtained in this wheel; the tire can be worn, and turned up in the lathe when needed, and again worn until all the steel is worn down to the cast-iron, without any danger of the tire bursting and flying off, or stretching and getting loose on the centre of the wheel—thus entirely doing away with all tire fastenings; the tire can be welded on from one-fourth to two inches in thickness, or more as desired, of any required form of tire or wheel; if a steel tire, 2½ inches in thickness, is shrunk upon the wheel under the present system of tireing, little can be used in consequence of the great strain and shrinkage, which renders it very unsafe, and it has frequently to be replaced with a new tire; whereas in the case of a wheel when once welded to the tire any thickness, under this patent, the actual use of all the tire is secured with perfect safety, thus effecting an enormous saving in the cost of this wheel; finally, by this system, lighter steel tires may be used than is safe to use in any other way, as this tire increases the life of the wheel probably 50 per cent. over any other known process. The above patents also apply to the driving wheels, and will be found specially adapted to narrow-gauge railways.

There are rich collections of all varieties of cutlery, of small weapons, tools, locks and keys, safes, chains, needles, pens, etc.

[1] Dr. A. W. Williamson gives 885·3 units as the result of his calculation, which two figures agree sufficiently for my present purpose.

to be met with in the galleries, but space forbids us to do more than just mention them in this general way.

Of foreign countries Sweden alone seems to be appropriately represented. The objects exhibited by the "Central Swedish Iron and Steel Company," Bjorneborg; W. O. Croneborg, Molkom; the "Dannemora Cast Steel Company," Dannemora; the "Fagersta Iron Works," Westanfors; the "Husquarna Small Arms Manufacturing Company," Jönköping; M. Alfort, Stockholm, and the "Motala Mechanical Manufactory," Motala,—all of them give evidence of the continued high state of iron and steel production of the northern Peninsula.

France sent us only some curious old cutlery through Didier and Vezoux, Thiers (Puy-de-Dôme); A. Juvinal, and P. de St. Albin, both of Paris, and Belgium is represented merely by some steel jewellery exhibited by J. Wurden, of Brussels.

Of Germany there is absolutely no direct representation. The only things that remind us in South Kensington of the iron industry of the new empire, are some crank axles made of cast steel by Krupp's crucible process.

The Swiss iron and steel production is brought before us by Müller Brothers, of London and Geneva, who exhibit files, and watchmakers' and jewellers' lathes and tools.

From the United States we meet with but a single exhibitor, Park, Brothers, & Co., of Pittsburgh, Penn., who exhibit fine specimens of homogeneous cast-steel for boiler and fire-box plates, and bars of tool-steel. The firm kindly inform us that the iron used in the manufacture of the boiler steel is from "the Iron Mountain," Missouri, distant about fifty miles from the city of St. Louis, Mo. The iron ore from "the Iron Mountain" is reduced to pig by the use of charcoal in an ordinary blast-furnace, then bloomed, and rolled into bars. These bars are cut up and melted in "plumbago crucibles," capacity of each crucible eighty-five pounds. The carbon necessary to cause the iron to melt comes from the plumbago of which the crucibles are made. A heat of 2,800° to 3,000° F. is required to melt the iron. They employ both the ordinary coke-melting furnaces, similar to those used in Sheffield, but somewhat larger, and the Siemens gas regenerative furnaces. They use as many as twenty-two crucibles full of metal in a single ingot, and roll plates as heavy as 1,700 lbs. when finished. The steel contains $\frac{2}{10}$ per cent. of carbon, and is remarkable for its strength and ductility. Messrs. Park, Brothers, & Co. recently furnished between thirty and forty tons of the homogeneous cast-steel boiler-plates to the owners of the "Mary Powell," a Hudson river steam-boat, believed to be the fastest steamer in the world; the specimen shearings taken from these plates pulled asunder under an average strain—measuring the original area of the specimens at the breaking-points—of 69·103 lbs. to the square inch. Yet the same specimens, taking the measured sizes of the fractured areas, gave the breaking strain of 122·820 lbs. to the square inch. In making tests for elongation, it was found to be nearly 3″ to the foot before rupture.

A trial boiler made of this steel 38 in. diameter, by 8 ft. long, was tested by the United States Government Boiler Inspectors by hydrostatic pressure; at 780 lb. the rivets in one plate sheared, preventing them from knowing what pressure the plates would withstand. The boiler plates were double riveted with $\frac{5}{8}$ in. iron rivets. At 780 lbs. pressure, the circumference of the boiler was enlarged $\frac{3}{16}$ in., showing great ductility in the metal. The plates were $\frac{1}{4}$ in. thick. The introduction of the steel boiler-plate referred to, is as yet limited. The custom is now becoming general with the United States railroad companies, to use steel in the construction of the fire-boxes of their locomotives, and some of them are using it in the shells of their locomotive boilers.

In reply to our inquiry regarding the composition of the ore from which the homogenous cast-steel is produced, Messrs. Park Brothers and Co. have sent us a recent analysis made by Dr. O. Wurth. The samples were chosen by breaking numerous small bits of ore from every part of the mine, and give a safe average of the ore as it would be worked in the furnace.

1. Surface ore. Dried at 115° C.

Specific quartz	5·002
Silicic acid	3·02
Alumina	0·06
Lime	0·32
Magnesia	0·21
Protoxide of iron	0·86
Peroxide „	95·42
Manganese	0·07
Phosphoric acid	0·036
[Corresponding to phosphorus	0·016]

2. Quarry ore. Dried at 115° C.

Specific quartz	4·944
Silicic acid	4·75
Alumina	0·08
Lime	0·46
Magnesia	0·23
Protoxide of iron	0·76
Peroxide „	93·57
Manganese	0·12
Phosphoric acid	0·035
[Corresponding to phosphorus	0·015]

Both ores are free from even minutest traces of sulphur.

Professor Bush, of Yale College, recently analysed the iron mountain ore, for the purpose of determining the amount of phosphorus, with following result.

	One sample.	Another sample.
Surface ore	·043	·026 per cent.
Quarry	·043	·042 per cent.

So far as phosphorus is concerned, the ores are good for iron for Bessemer steel. Thousands of tons of the charcoal pig-iron made from "Iron Mountain" ore are used in this country for the manufacture of Bessemer steel. The present price of this charcoal pig is high, being $60 per ton in Pittsburgh. Ordinary coal and coke irons, made from Lake Superior ore, are worth $38 per ton on four months' time. What is termed as surface ore is that found in the shape of boulders all over the mountain and about its edges. That termed quarry, is what is mined out from the mountain. Price of bar iron, 3 $\frac{8}{10}$ *cts.* per lb.; price for puddling $6 $\frac{80}{100}$ per ton of 2,240 lbs.; extra $1 per ton allowed during June, July, and August, the three hot months, making the price now $7 $\frac{80}{100}$. During these three hot months, puddlers are required to work with two helpers. Puddlers pay their helpers out of the $7 $\frac{80}{100}$.

N.B.—The amount of cast steel made in Pittsburgh is about 30,000 tons per annum.

Best quality of coke 7 *cts.* per bushel, or $4 $\frac{48}{100}$ currency per ton of 2,240 lbs. delivered.

Prices of coal in Pittsburgh, delivered at the furnaces. Large lump 8$\frac{1}{2}$ *cts.* per bushel, or $2.55 currency per ton of 2,240 lbs. Nut coal $1 $\frac{50}{100}$ and slack $1 $\frac{20}{100}$ per ton of 2,240 lbs.

HYDRAULIC GUNNERY.[1]

THE importance of protecting our commercial harbours from the sudden inroads of hostile ironclads was forcibly argued by Sir William Armstrong in his letter on "Harbour Defence," dated the 20th of May, 1869, which appeared in "The Times" of that date.

Since that date the soundness of the tactics then advocated—namely, an attack by a number of small barge-like steamers, or floating gun-carriages, each armed with one very heavy gun—has been fully recognized, and the plan is now incorporated in our system of coast defence.

The class of vessel suitable for this nature of warfare was, in 1869, represented by the "Staunch," an unarmoured gunboat, designed by Mr. George Rendel, of Elswick. The "Staunch" is 79 ft. long, and 25 ft. beam; her draught of water when loaded is 6 ft., and her displacement 150 tons. She carries a 9 in. rifled Woolwich gun, throwing a shot of 250 lb. with a charge of 50 lb. The gun is mounted upon a platform, which can be raised to the surface of the deck or lowered beneath it by means of four large screws, in connection with machinery driven by a donkey engine. Thus the gun can be safely and securely stowed away at all ordinary times, and can also be rapidly brought into action when required.

A comparatively large number of "Staunches," each armed with a powerful 10-inch rifled gun, has now been added to our navy, and by acting in concert and from various points these vessels will form, as it were, the skirmishers of a defensive naval force, and will thus prove valuable auxiliaries to our ironclad fleet.

The gunboat "Hydra," which on Saturday last was tried off the mouth of the Tyne, in presence of Major-General Wilmot, R.A., Captain Boys, R.N., Colonel Close, R.A., Major Tyler, R.E., Captain de Fremery, the Dutch Director of Naval Ordnance, Major Moncrieff, and other officers, is of the same character and of nearly the same dimensions as the "Staunch," but embodies a peculiar feature in her construction which renders her experimental trial of greater importance than it otherwise would be. The hull of the "Hydra" was built for Sir W. Armstrong and Co., by Messrs. Charles Mitchell and Co., the well-known shipbuilders on the Tyne. Her dimensions are—length, 80 ft.; beam, 25 ft.; depth of hold, 8 ft.; height of bulwark, 2 ft. 9 in.;

[1] From "The Times" of July 23rd, 1873.

draught, 6ft.; displacement, 150 tons. She is fitted with twin-screws, driven by a pair of compound engines of 15 horse power (nominal) each, designed by Mr. J. F. Spencer, with a special view to great economy of fuel, and manufactured by Messrs. Jackson and Watkins, of Poplar. Thus in general dimensions there are many points of similarity between the "Hydra" and the "Staunch;" but they differ in one important point—namely, the method in which the gun is mounted. This in the "Hydra" is such that the gun each time it is fired recoils below the deck into a position where it can be loaded by men placed beneath the deck, and comparatively under cover.

The ingenious idea of mounting a gun in this manner originated with Major Moncrieff, who proposed to store up and thus utilize the force of recoil. Major Moncrieff has proposed to effect this by two distinct and separate processes. In the one now adopted in the land service for guns up to the 9 inch, of 12 tons, the force of recoil is stored up in raising a counterweight. As the gun sinks below the parapet the counterweight rises and is held by a paul. The liberation and descent of the counterweight restores the gun to the position for firing. But for the naval service, Major Moncrieff proposed to abandon the counterweight, and to store up the force of recoil by making the gun, when fired, drive back a plunger or piston, which forced water, through a valve, into an air vessel. It was considered that the air, thus compressed, would become a spring, and have sufficient power of expansion, when released, to return the plunger, and consequently the gun, to the firing position.

This was the theory of the operation, but it is doubtful whether the method would ever have advanced beyond the theoretical stage were it not for the enterprize of the Dutch Government. The latter had ordered a gunboat of the "Staunch" class, and Sir William Armstrong and Co. induced them, by a guarantee of success, to adopt the hydropneumatic, or rather hydraulic, method of mounting the gun. We say hydraulic, because in carrying out the details of the novel process, the success of which they had guaranteed, Messrs. Armstrong had to abandon attempts to utilize recoil, as originally proposed by Major Moncrieff, and were obliged to fall back upon hydraulic machinery, which differs little from that introduced by them many years back and now universally known in its application to more peaceful purposes. Thus, in the gun carriage of the "Hydra," the recoil is not utilized, but a small steam-engine raises the gun by pumping into the lifting presses. When the gun recoils, its fall is governed by causing the water in the presses to escape through a weighted valve and through a self-acting throttle valve; by this means the recoil is adjusted with such nicety as to stop the gun exactly in the loading position whatever may be the amount of the charge, or the inclination of the vessel at the moment of firing. The gun of the "Hydra" is a 9-in. 12-ton gun, of the same class as that originally mounted in the "Staunch."

As the gun can only be moved in a vertical plane parallel to the keel, it can only be directed on an object by moving, as in the case of the "Staunch," the vessel itself. This can be effected with great ease and rapidity, owing to the form and dimensions of the vessel, by a motion of the rudder, or, if the boat has no way on, by working one of the twin engines ahead and the other astern. But in order to bring the motion of the vessel under the direct control of the captain of the gun, Sir W. Armstrong & Co. have devised a very simple form of direct acting steam-steering gear, which is worked by a small lever placed immediately behind the gun in the firing position, and furnished with an indicator showing at all times the exact position of the rudder.

A telegraph to each engine also stands beside the above lever, so that the motion of the machinery is under the direction of the chief operator. Close by is placed a lever for working the valves of the hydraulic machinery by which the gun is raised and lowered, as well as the magneto-electric apparatus for firing. Thus one man standing behind the gun, in a position to look over the sights, has under his command all the movements necessary to raise the gun to the firing position, to lay it on the object of aim, and to fire, and these operations are performed by one person with an ease and rapidity that must be seen to be fully appreciated.

The "Hydra" left the Elswick works at 10 a.m. on Saturday morning, and steamed down the river, arriving off Tynemouth about 12.30 p.m. On the way down the river the party on board inspected the hydraulic machinery at work on one of the Hopper barges. There are three of these barges in the Tyne, each carrying a 27 cwt. hydraulic crane fitted with an air accumulator exactly as in the "Hydra." The first of these was made in 1865; the others in 1867. On arriving in open water the vessel was cleared for action and fired seven rounds of 250 lb. shot, four with the battering (50 lb.) charge, and three with the ordinary (30 lb.) charge. The machinery worked in the most perfect manner, the gun recoiling each time, irrespective of charge, exactly to the loading position; and the marvellous ease, rapidity, and certainty with which the whole operation, including loading, steering, laying, and firing, was performed by three men, commanded the admiration of all on board.

It may be a question in the opinion of some authorities whether the increased protection which this system affords to the gun's crew, as compared with that adopted in the "Staunch" gunboats, is not too dearly purchased at the expense of the additional machinery involved. But the question must not be looked at from the narrow view suggested by a mere gunboat; the trial of the "Hydra" has demonstrated that Sir William Armstrong and Co. have successfully solved the difficulty of applying hydraulic machinery to a rising and falling gun, and have practically carried out a principle that may prove invaluable in its application both to land defences and to armoured ships of war. We have little doubt that the application of hydraulic power to the working of heavy artillery has a great future before it. Ten years ago the heaviest gun mounted in Her Majesty's fleet weighed about five tons. The "Devastation" and "Thunderer" now carry 35-ton guns. What will be the weight of the gun of 1883? We have now arrived at a point beyond which manual labour will fail, unless assisted by machinery. If we require 1,000-pounders and 1,500-pounders, we must work such guns by hydraulic or other similar agency. Fortunately we can do this. We have ample means in accumulated wealth, abundance of mineral products, productive energies, and engineering skill, which, properly applied, must render us predominant in scientific warfare. We look, therefore, upon the successful trial of the "Hydra" as an epoch in the progressive history of gunnery, and we are glad to learn that the Admiralty have already taken steps to secure some of the advantages of the new system.

We understand that Sir W. Armstrong and Co. have been requested to apply their system of hydraulic machinery to the two 35-ton guns in the foremost turret of the "Thunderer." We shall thus obtain practical evidence of the efficiency of the method of hydraulic loading, traversing and general working of heavy guns, recently devised by Mr. George Rendel, of Elswick, while at the same time we may find it possible, with the aid of machinery, to increase the length and consequently the power of the gun, as well as largely to augment the rapidity of fire.

Thus we must not look upon the trial of the "Hydra" from a mere "gunboat" point of view. The successful application of hydraulic machinery to the working of heavy guns is a problem the importance of which can hardly be over-estimated. Provided we can keep the explosive force of gunpowder under our control by a mechanical arrangement of the size or shape of the individual grains which collectively compose the charge, and at the same time control the movement of the gun by an application of mechanical power, there appears to be no limit to the size of ordnance: and in a few years' time we may come to look upon the 700-pounders of the "Devastation" as mere popguns.

DIAMOND CUTTING AT THE WORKS OF M. COSTER, AT AMSTERDAM.

(*From "Les Grandes Usines," by* M. TURGAN.)

THE diamond plays a grand rôle in an epoch that is for men modest and laborious, but that for women is full of vanity and ostentation; formerly reserved for fortunes lofty and assured, it has to-day become the indispensable accessory of every adornment that has pretensions to a place in our modern Vanity Fair; and the sorriest marriage outfit must needs include at least one diamond, be it no larger than a pin's head. Thus what an overflowing is there now of wretched stones, cracked, blemished, discoloured, and incompletely cut, so as to leave as much weight as possible! To make these defective stones pass at all, the jewellers of the present time are driven to persuade the ladies that gold mountings are much more distinguished than the ancient silver mountings; for the yellow hues of gold extinguish those of the stone, as much as the whiteness of silver betrays and exaggerates them. They are thus able to satisfy the cravings of a false luxury with heaps of stones the faults of which should have destined them to be ground to dust to polish other diamonds, for they themselves would not even be of service to the glaziers, who require special forms.

But if a mediocre diamond is below all the other gems that jewellers use, below even imitation paste stones as they are made to-day, what shall we say of a beautiful genuine Golconda diamond, well cut as a brilliant, limpid and luminous, giving out

sometimes in the midst of its coloured fires the radiant scintillations of a star? This is no longer a miserable plaything for human vanity, but a marvellous product of creation, full of problems for the artist and the savant. What is a diamond? The definition is not very certain even now, and yet has occupied much attention from our chemists. Probably the latest scientific convention would agree, as we do, to what M. Dumas formerly stated in his lectures, that the diamond is a crystal composed of pure carbon with a double molecule, that is to say, in which the primitive molecule shall have twice the density of a molecule of ordinary carbon.

The presence of carbon is very certain, for if we submit the diamond, placed in a red-hot porcelain tube, to a current of oxygen, we obtain carbonic acid. In the year 1800, Clouet, Welter, and Hachette made an experiment at the Polytechnic School, in which they submitted to a very ardent fire a diamond weighing rather more than four carats, together with sixty times its weight in iron: the result was an ingot of steel.

According to M. Barbot, who made such long and persevering studies upon this subject, the diamond cannot be a pure carbon.[1] It contains a feeble quantity of oxygen; for it can burn itself away in an air-tight vase, and if it be burned in the open air the ignition is marked at certain moments with the sudden intensity of an extraordinary flash. It does not include the slightest trace of hydrogen, for burned in chlorine it exhibits no symptom of hydrochloric acid. The diamond contains neither silicate nor earthy matter, for burned in oxygen it leaves, when originally perfectly colourless, no residue at all.

It is rendered electrical by rubbing, but it does not retain that condition for long, twenty minutes at most; while the white topaz of Brazil remains charged with electricity for thirty-two hours. Emeralds and sapphires preserve the electric state for from five to twenty-four hours.

The diamond, especially in the rough state, is phosphorescent and luminous, not only in direct insolation, but as M. Barbot says, even through a tolerably thick wrapper, such as one or more double folded sheets of paper, a piece of chamois leather, a deal shaving of 0·020 millimetres in thickness.

It refracts light strongly, and decomposes the rays energetically; this it is that gives it the power of throwing out sparkling and many-coloured fires. This power of refraction may be reckoned at 1·396, that of water being 0·795.

In the rough state we find it in very fantastic forms, sometimes pretty regularly crystallized in the semblance of two pyramids united by one base, sometimes as an octahedron or dodecahedron, more or less elongated; at other times they are two twin crystals; but oftenest, and especially when they have been rolled and polished in a river-bed, the stones have no determined form. The diamond may be split easily enough when once the junction-point of the crystallized flakes are found. Certain diamonds, known in the trade as *bord* (smooth), are of a crystallization so perplexing, that it is impossible to cut them, sometimes even to polish.

Finally a species of amorphous diamonds, called *carbon*, was discovered at Bahia, about the year 1843; but these have nothing in common with the other diamonds but their hardness. Incapable of being cut, the *carbon* can be pulverized, and serves to polish the crystallized diamond as well as any of the other precious gems. It costs only four or five francs per carat, while even the *bord* is worth from twenty to twenty-five francs.

From time immemorial the diamond has given rise, especially in the East, to a crowd of legends more or less fabulous, and even to-day the information we can gather is very vague and uncertain. Reynaud, quoting Teifaschi, an Arab author of the thirteenth century, after having enumerated divers stories accredited to this period upon the properties of these precious stones, adds :—

"Speaking of the diamond, Teifaschi relates that the places where this stone is found are situated only in awful and desolate valleys, where the foot of man has never penetrated; the diamonds lie there scattered like grain or barley; to procure them, they throw into these places lumps of raw meat, which eagles and birds of prey hasten to pick up, and as while they lay there, the little stones adhered to them, the diamonds drop out in the birds' flight, and are gathered up by the searchers."

The narratives of other travellers, without, however, confirming Teifaschi's story, speak of the difficulties that are found in penetrating to the mines, situated, almost all of them, in the mountains that guard the Indian peninsula. The names of Golconda and Visapour are always connected with the history of famous diamonds, and with justice; for even to-day it is still at Parteal, or within some miles of this town, that the mines containing diamonds of the finest water are to be found. The authors who have written upon the diamond mines of the East Indies have more or less paraphrased Tavernier, and almost all of them, one after another, without going to the authority itself. We have ourselves directly consulted the works of this justly celebrated traveller, and we have been astounded at the wonderful amount of information contained in his volumes. Tavernier, after spending forty years in exploring Turkey, Persia, and the English and Dutch colonies in the East Indies, determined that he would go and see the mines in which the diamond was found :—"I have been in four mines of which I give you a description, and I have met none of those difficulties, none of that barbarous treatment, with which the gentlemen who knew the maps of those countries but sorrily thought to affrighten me." He first visited Raolconda, five days distance from Golconda, nine from Visapour; there he found a district "sandy, full of rocks and brushwood, not unlike the environs of Fontainebleau." At this mine they gather diamonds of the very finest water, but they are always injured by the blows of the miner's pick, which "astonishes" the poor diamond. Likewise when the miners see a stone larger than usual, "they set themselves to cleaving it, in which they are more *practised* than we are." These miners of Raolconda, though, are skilful fellows; for "if there be any flaws or cracks, or a spot of black or red sand, they cover all the stone with facets, so that the faults cannot be seen; and if there be a flaw of the smallest size, they conceal that under the edge of one of the facets. But it must be noticed that merchants like a black spot in a stone better than a red spot, so when there is a red spot they burn the stone and it becometh black." It was also at Raolconda[1] that Tavernier saw a number of diamond cutters so skilled in diamond cutting that they could cut diamonds, the hardness of which

[1] "Our experiments, decisive and frequently repeated as they have been, convince us that the combustion of the diamond takes place spontaneously between 2,750° and 2,800° Fah., and that once alight its destruction is very rapid, and that its quick combustion, which is by reason of its coloration, lasts in proportion to its size.

"The diamond, when on the point of burning, is never liquid; it is full, solid, always dense; its constituent molecules are only dilated by the force of heat. In this state it seems as though puffed out, appearing much larger than it really is. Suddenly it bursts into flames all over; the flames envelope it entirely with a white and lively aureole. The electric spark at its maximum can scarcely give an idea of this flashing brilliancy; and then it burns in the manner of cork, that is to say, the flame is only exterior, but embracing all its surface, so that we can reduce it to its simplest expression without losing anything of the primitive form. The slightest accidents of crystallization, the cavities, the deviations of form, the striæ, &c., all are scrupulously preserved. We have often proved, in burning the diamond in the open air, that its flame takes more vivacity and extension at certain moments, without anything appearing to produce this effect, our heat remaining stationary during this operation. We have been compelled to consider this effect as produced by the oxygen, which, according to our belief, the diamond contains, and which, by its sudden sortie, has augmented the intensity of the flame. Thus we are very firmly convinced that the diamond should be considered and chemically named as *protoxide of carbon*."—BARBOT, *Guide Pratique du Joaillier*.

[1] "There are at this mine a number of diamond cutters, and each of them has merely a steel mill, scarcely larger than our common dinner-plates. They put only one stone on each mill, incessantly drenching the wheel with water, until they find a road into the stone. The road once found, they take oil, and do not spare diamond powder as being of great value, so as to finish the stones off more speedily, and they weight them much more heavily than we do. I have witnessed them put one hundred and fifty pounds of lead upon one stone; certainly that was a great stone, which remained at three hundred carats after having been cut; and then it was a grinding mill in our fashion, where the larger wheel was turned by four negroes. The Indians are not of the same opinion as we, and do not believe that pressure makes flaws in the stones. If theirs are not flawed, however, it is probably because they always have a little lad, who, holding in his hand a tiny spatula or spud of wood, incessantly souses the stone with oil and diamond dust. Besides that, their mill does not go so quickly as ours, because the wheel of wood which drives the wheel of steel is not more than three feet in diameter.

"They cannot give their stones so bright a polish as we do in Europe, and I think this arises from their mills not running so smoothly as ours. For as they are of steel, if they rubbed them with emery every twenty-four hours as should be done, they would have to take them from the axle, and they cannot be easily adjusted so as to run as smoothly as before. If, like us, they knew of the invention of iron mills for which no emery is necessary, but which may readily be filed without removal from the axles at all, they could give their stones a much better polish than they do. I said that it is necessary to rub the mills with emery, or file them, every four-and-twenty hours; but this should be done at least every twelve, if the workmen be not idle. For when the stone has run a certain time, the part of the mill on which it has been pressed becomes as polished as a glass mirror, and if it be not roughened again by emery or the file, the powder will not stay where it is wanted, and in two hours you cannot do the work that otherwise could be done in one."—TAVERNIER, *Voyages*.

would have deterred any European workman. The police of the mine seem efficiently managed; the merchants giving two per cent. of their purchases for aid and protection. Those who come to the mines "to do business," remain in their own domiciles, and every morning from ten to eleven o'clock, the master miners "after having dined" bring them the lots of diamonds, which are left in their hands seven or eight days for examination. After that time the bargain must be instantaneously concluded, otherwise the master-miner places his lot of diamonds "in a corner of his girdle, his shirt, or his turban, and you never see again the stones you have once refused."[1] The payments are made through the mediation of the cherafs or negotiators who are answerable for the quality of the gold pieces, named *pagodes* (worth a demi-pistole) given by the foreign merchant.

The governor watches over the safety not only of the merchant personally, but even of his gold; giving him guards, and pushing kindliness so far as to have all the stones he may purchase gratuitously weighed by a special official who is answerable as to accuracy to both parties.

The second mine visited by Tavernier was that of Gani, or Coutour, whence came the diamond which Tavernier describes in his account of the Great Mogul's jewels. The stones there are larger, but less pure than elsewhere. Sixty thousand persons, men, women, and children, were working in this mine at the time of his visit. After having constructed a kind of walled cistern, they throw into it all the earth which they suppose contains diamonds, then they flood it with water to detach the stones from the soil. When it has dried up again, they shift and shake it until the precious pebbles are visible to the eye.

The third expedition that our intrepid traveller took was to explore the sands of the river Gouel, near the village of Soulmelpour. During the rainy season the floods, pouring down from the mountains, whence the Gouel issues, wash the diamonds on to the level plains, and subsiding again in the month of January, leave a deposit of mud and sand two feet thick, in which they find the best naturally pointed diamonds.

From these several voyages Tavernier brought to Louis XIV. twenty stones of the finest water, of which the largest weighed 112 carats, being of a beautiful violet colour, another rose-coloured 14 carats, and a third, finely cut, 10 carats. The smallest weighed at least 7 carats.

Even to-day, the chain of the Ghauts, lofty volcanic mountains which form, after a fashion, the skeleton of the Indian peninsula, contain numerous mines. The streams that take their rise in these valleys carry down with them a considerable quantity, and the rivers Gouel, Krishnah, and Mahynady supply the markets of Benares and Bowanipore. In the island of Borneo, close to the town of Landak, is found one of the richest mines in the world, and the diamonds which are discovered there are almost always cut on the spot.

At Sumatra, at Java, in the Celebes, we sometimes come across soils which contain this precious gem, and several diamonds have been discovered at Carthagena, in Spain, at Adolph on the banks of the Bissersk, in Siberia, and even in the auriferous river of Goumel, near Constantine. The journals of to-day are announcing an exhibition of diamonds found in Australia, which is taking place at Victoria (1870). But all these localities were unable to in any way affect the fortunes of the Indian mines, while on the contrary, the profitable exploration of the Brazils threw a very large number of diamonds upon the trade, and entered into immediate rivalry with the wealthy Indian monopolists, who allow the stones, slowly accumulated by them, to cir-

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[1] "One day, about even-song, a Banian, very poorly attired, having nothing but a girdle round his body, and a sorry kerchief on his head, came civilly up to me, and seated himself by my side. In this country one does not take much heed of a man's garments, for such a one as only has a scanty yard of cloth around his loins may sometimes carry in it a good store of diamonds. On my side I paid my civilities to the Banian, and, after he had been sitting some time, he asked me, through my dragoman, whether I wished to purchase any rubies. The dragoman said that they must first be seen, and then he drew a quantity of little cloths from his girdle, in which there were about twenty rings of rubies. After having well inspected them, I said they were too small for me, and that I wanted large stones. Nevertheless, remembering that I had been requested by a lady of Ispahan to bring her a ring of rubies of about a hundred crowns in value, I bought one of these rings, which scarcely cost four hundred francs. I knew well enough that it was not worth more than three hundred, but I willingly ventured this extra hundred francs, in the belief that he had not come to me for these rubies only, for I saw easily from his manner that he wished to be alone with me and my dragoman, to show me something better. As the prayer-hour of the Mahommedans approached, three of the servants whom the governor had given me went to pray, and as the fourth remained to wait on me, I sent him away to buy bread, and he was quite long enough for my purpose; for all the natives of this country being idolaters, he contented himself with rice without eating bread, and when he wished to have the latter it was necessary to go a considerable distance, to a fortress belonging to the king of Visapour, where there were only Mahomedans. This Banian, then, seeing himself alone with me and my dragoman, after having made many fashions, took off his turban, untwisted his hair—which, according to custom, was knotted on his head. Then I saw issue from his locks a little scrap of linen, in the which was wrapped a diamond, weighing 48½ of our carats, of the finest water, polished, but not cut; three-quarters of the stone perfect, in spite of a little dirt on one side, that seemed to go a little way into the stone. The other quarter had red spots.

"As I considered the stone, the Banian, seeing the attention with which I regarded it, said, 'do not trouble yourself to look at it now, you shall see it to-morrow morning at your leisure, when you shall be alone. When a quarter of the day has passed (it is thus they speak) you will find me outside the town, and if you wish for the stone, bring me the money;' and he then added how much he desired. I must remark in passing that after this quarter of a day the Banians, women as well as men, return to the town or village where they dwell, as much to satisfy the ordinary necessities of nature and to wash their bodies afterwards, as for the prayer their priests are making. The Banian appointed this time because he did not wish that anyone should see us together. I did not fail to go and find him, bearing with me the sum of money he had asked, but putting on one side two hundred pagodes of this amount as a reserve. At last, however, after he had abated somewhat of his price, I was forced to give him one hundred of these. On my return to Surat I sold the stone to a Dutch commander, and by it I turned an honest penny.

"Three days after the purchase of this stone, there came to me a messenger from Golconda, on the part of an apothecary called Boëte. I had left him at Golconda to receive and keep a part of my capital, and, in case the cheraf paid in rupees, to change them into pagodes of gold. On the day after receiving the payment, he was seized with such a looseness of the bowels, that a few days after he died of it. By this letter he informed me of his malady, and that he had received the money, which was all in his chamber in sealed bags; but as he did not believe he could live more than two days, he exhorted me to hasten my return, because he had no confidence that my money would be safe in the hands of the attendants I had left with him. So soon as I received this letter, I hastened to the governor, to take my leave of him; at which he was astonished, and asked if I had spent all my gold. I replied that I had not invested one half, and that I had still twenty thousand pagodes well told. He said that if I wished he would employ them for me, and that I should assuredly lose nothing by what he might purchase. Moreover, he asked if I would allow him to see the rubies I had bought, though they could not have been unknown to him, because those who sell are obliged to declare the facts before him, on account of the two per cent. due to the king from those who buy. I showed him, then, my purchases, told him what they had cost, which agreed with the entry in the official books. At the same time I paid the two per cent. for the king's dues. Having received this, he said it was very clear that the French were a nation of good faith. Of this he was still better persuaded, when drawing out the stone of 48½ carats—'Seignior,' quoth I, 'this is not entered in your books, and not a soul in the town knows that I have purchased it, nor would you know unless I declared it unto you. I wish not to defraud the king of his rights; behold what belongs to him of the sum which the stone has cost me.' The governor appeared very surprised, and altogether much edified with the proceeding. He praised me heartily, and told me I had acted as an honest man, and that there was no merchant in the country, be he Mahomedan or idolater, who would have used him in the same way, if he thought that nothing was known of the purchase. Thereupon he called together the wealthiest merchants of the place, and having related the thing unto them, commanded them to bring hither the finest stones they had; and this three or four did, and thus I spent my twenty thousand pagodes in an hour or two. The bargain made and the money paid, he told the merchants that, having dealings with an honest man, they should give me somewhat as remembrance, the which they did with a good grace, bestowing on me a diamond, worth nearly a hundred crowns. As for him who was the governor, he made me a present of a turban and a girdle.

"I have here to make a remark very singular and curious anent the manner in which the Indians, idolaters as well as Mahometans, make their sales in all sorts of merchandise. All passes in silence, without a single person speaking. The seller and the buyer sit one before the other like two tailors; one of the two opens his girdle; the seller takes the right hand of the buyer and covers it with the fold of his girdle, under which, in the presence of several other merchants, who sometimes meet in the same hall, the bargain is secretly accomplished without any one being privy to it. For the buyer and the seller speak neither with the mouth nor yet with the eyes, but only with the hand, which is done in this manner: when the seller takes the buyer's whole hand, that means to say one thousand, and as many times as he presses it, he means so many thousand pagodes or rupees, according to the currency in question. When he takes only five fingers, that signifies five hundred, and if he takes one it means one hundred; taking half, to the middle joint, conveys fifty, and the end of the little finger, as far as the first joint, only ten. Such are the mysteries that the Indians lend to their bargains, and it often happens that in the same place, where there are many people met together, the same lot is sold and re-sold seven or eight times, without the company knowing for what it has gone."—TAVERNIER.

culate in moderate numbers only, so as to keep up the market price.

About the year 1729 Bernard de Fonseca discovered in the Sierra de Frio the first diamond bearings on the American continent. This district was explored almost as far as Bahia and Rio Janeiro, but in spite of some rare exceptions, they do not find in the Brazils diamonds of as fine a water as in India.

The principal mine in the Sierra de Frio is Mandaga, close to Tejuco. It was here that some of the Portuguese followers, having one day picked up carelessly a number of pretty pebbles, thought they were fine enough to be offered as a present to the governor of Villa de Principes. He, after having used them as card-counters, sent them to Lisbon, from whence the Dutch ambassador forwarded them to Amsterdam : there they were recognized as true diamonds. Starting from the time of the discovery, the Brazils despatched to Europe about 150,000 carats annually, but the supply gradually diminished until the new mines were found in Tihigi, by the rivers of Andaya and Malhoverda, and above all in the lava of the Sierra de Bahia.

The Brazilian diamonds, which now keep almost entire possession of the European markets, were at first subject to much doubt. Jeffries even maintained that the true stones sold as the first of the Brazilian species, were genuine Indian diamonds, brought into Portugal by way of Goa. The same author adds that the quantity thrown on the markets in 1733 was large enough to lower the price to a single *louis* per carat. These Brazilian diamonds consequently fell into such discredit, that the merchants, to obtain a sale at all, were obliged to have them cut *en biseau*, after the manner of the old Indian stones. They have, however, greatly risen in value since, and now they alone, or almost alone, supply the diamond-cutting establishments of Amsterdam.

The mines of Brazil have recently furnished a very beautiful stone, and we borrow a detailed description from the excellent "Chemistry" of MM. Pelouze and Fremy :—

"This stone, christened the *Star of the South*, was found in 1853 by a negress employed in the mines of Babagem, in the province of Minas-Gereas ; it is the largest diamond that has ever come from the Brazils, weighing in the rough 254½ carats. The owner, Mr. Halphen, before sending it to be cut, entrusted it to M. Du Fresnoy for a careful study of the form, which was that of dodecahedron, bearing an obtuse *biseau* on each face. It was flattened on one side ; its unpolished surface was rendered slightly rosy by *striæ*, of which some, disposed in a regular manner, exhibited traces of octahedric clefts, proper to the diamond ; the other *striæ* formed a kind of very fine sand ; its specific gravity is 3·529. The dimensions of this diamond were as follows (fig. 7) :—from F to G, ·042 m.

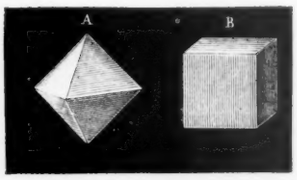


Fig. 1.

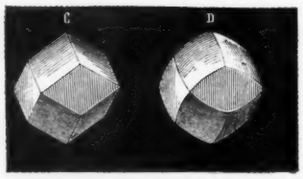


Fig. 1.

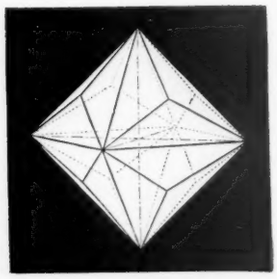


Fig. 2.

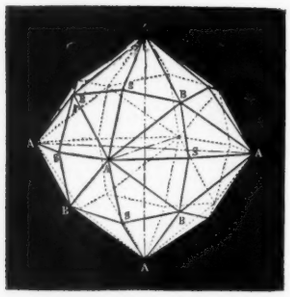


Fig. 3.

"One of the faces of this diamond presented an octahedric cavity, tolerably deep (fig. 7) ; this represents the impression left by a diamond crystal which had formerly been implanted on the surface of the *Star of the South*.

"The interior of this cavity, examined with a magnifying glass, displayed well marked octahedric *striæ*. You can also see the traces of three other diamonds which had been grouped upon the principal diamond.

"The posterior face of the *Star of the South*, again, bears traces of two diamonds which had been detached at the period when it was washed away in some flood. The base of the diamond exhibits at *d* (fig. 7) marks of the adherence of several other little diamond crystals. On this side we see a smooth part where the cleft appears.

"The *Star of the South* is to-day a splendid brilliant of 125¼ carats' weight, and of the finest water. It was cut at Amsterdam, at the workshops of M. Coster, where they were obliged to leave it for more than two months on the mill."

According to M. Barbot, the mines of Brazil had already given birth, among other great stones, to the most bulky diamond in the world, popularly known as the "King of Portugal's diamond." It was found in the Brazils in a place named Cay de Merin, near the little river Malhoverda, and weighs, so says M. Ferry, 1,730 carats, or, following Mauwes, 1,680 carats. It must be as large as a hen's egg, slightly oblong, of a deep yellow colour. According to the tables employed for calculating the approximate value of diamonds, it would, in spite of its faults, be worth seven milliards five hundred million francs. "Unfortunately," adds Barbot, "they pretend that it is a topaz ;" and it has not been cut, probably in the fear lest it should be unable to support the friction of the mill, as sometimes happens.[1]

Whether coming from India or the Brazils, the following,

[1] "About a year back an American had a so-called diamond as big as an egg, and asked fifteen million francs for it. He submitted it to the School of Mines, and then the authorities, after having examined its structure, and calculating its specific gravity, pronounced it a diamond. So at least the American declared. This stone being submitted to us, we at once understood that the mineralogists had been deceived by the weight of the stone, which is absolutely the same in the white topaz of the Brazils and the diamond, and gathering from other characteristics the true nature of the stone, which was a marvellous topaz, we enlightened the American, who, however, declined to believe us, so much does it cost to be disillusioned ; and then you understand . . . fifteen millions ! . . . Well, he returned in a few days to have it tested on the mill of M. Philippe, the diamond-cutter. In vain did the young workman prophecy a fatal result, he would listen to nothing, and insisted that the diamond should be placed on the platform ; at the first touch it was frightfully mutilated. . . . One turn of the wheel had shattered fifteen millions ! The American rushed out like a madman, and we saw him no more."—BARBOT.

according to Du Fresnoy, as quoted by Pelouze and Fremy, are the principal forms affected by the diamond in its crystallization :—

First, the octahedron (fig. 1, *a*), which generally is the dominant form, but the simple octahedron is very rare, as are also the cube (fig. 1, *b*), and the octahedric pyramid (fig. 2); the rhombic dodecahedron is very frequent, whether simple (fig. 1, *c*), or derived from octahedric form by a *pointement*, with six faces upon each of its facets, and thus constituting a hexakisoctahedron, or a solid with forty-eight sides (fig. 3). The triform (fig. 4) is very rare; the Museum of Natural History possesses a capital example of it. Where the forms belong to the regular system of crystallography, they are ordinarily modified by a great number of facets. In consequence of these modifications the sides of the diamond often appear crooked; at other times they really are so, and their intersections are made according to curvilinear edges. The crystals of the diamond sometimes appear as *macles*.

The School of Mines possesses a very beautiful diamond composed of two crystals crossed at right angles (fig. 5); the Museum of Natural History also has an equally interesting *macle*, under the form of a kind of rosette, composed of three dodecahedrons united in a triple angle (fig. 6). The dodecahedrons which form this *macle* have on their faces a quadruple *pointement*. There really are, then, crystals with forty-eight sides."

But it is not in general under these definite forms that the diamond arrives at our continental markets, twice a month, in steamers, the one French, the other English, which bear to us little lots of this greatly prized gem. In these lots stones of all weights, colours, and forms are mingled, and it is for the merchant who buys them to divine what they may become, and whether the last cutting will endow them or deprive them of the desired qualities. Their form is extremely irregular, and though always bearing evidence of crystallization, diamonds are for the most part round, some of a greenish, others of a yellowish hue; the greatest number grey; the most beautiful, those whose value is really assured, being colourless.

The crystalline form oftenest preserved is the simple *pointe* (fig. 1), but nearly all with worn edges, sometimes rounded. Stones weighing more than one carat are rare, especially when to their weight they add bulk or thickness, sufficient to allow them to be cut as brilliants, together with beauty of water and absence from flaws. For the workshop which we are presently going to describe, the diamonds are almost all purchased at Paris, which for many years has been the centre of the trade in rough stones.

The establishment of M. Coster is exclusively consecrated to

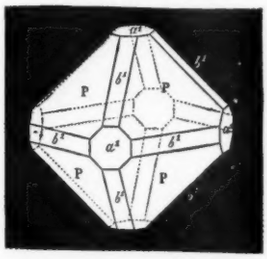


Fig. 4.

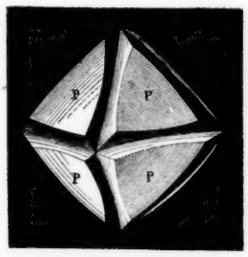


Fig. 5.

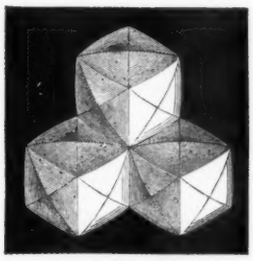


Fig. 6.

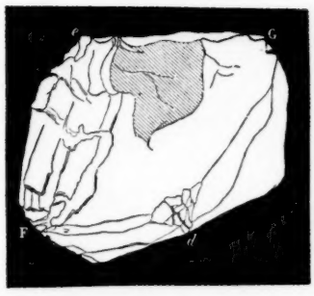
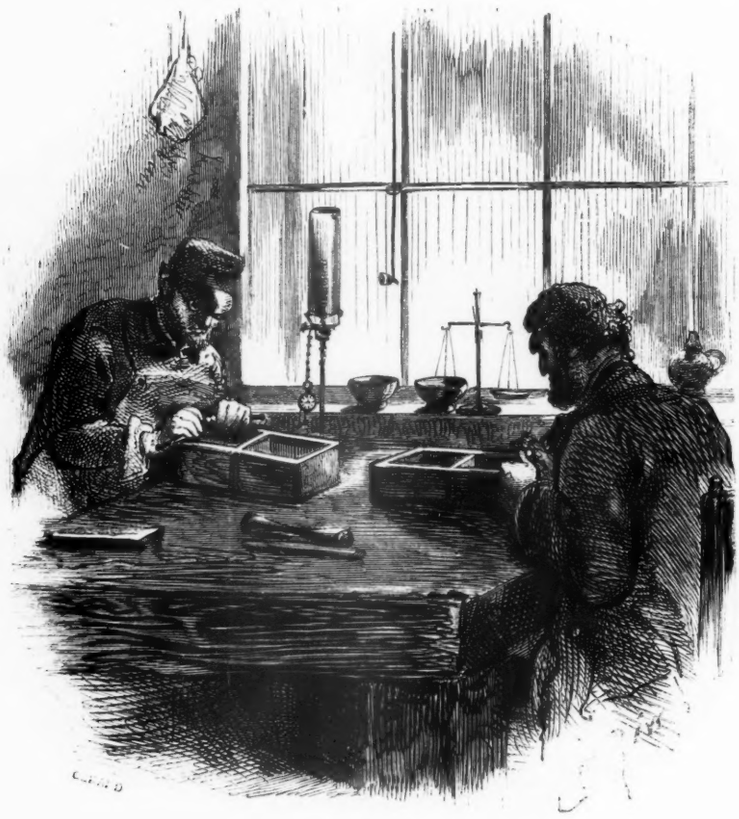


Fig. 7.

the diamond, no other precious stone being worked there. The operations to which this gem is submitted were for a long period quite unknown, and even to-day most of the persons who wear diamonds know nothing of the many stages to which they are submitted before acquiring that brilliancy which gives them all their value. The cutting-works, directed by M. Daniel, is by no means one of those vast manufactories, the buildings of which cover an immense area of ground, but it is an elegant, even coquettish brick building; one engine of seventy horse-power supplies all the power required. But the workshops are admirably formed; the light enters through clear glass windows, polished steel glitters all around, the steam-power, skilfully directed, works without any effort—everything declares that one is in a workshop *de luxe*. It is the single establishment of this importance belonging to a private individual; another is seen side by side with it, but this latter is rather a place where skilled workmen may be obtained than a workshop; and as to the establishment known in France as "the Imperial Diamond Cutting Works," it is still, in spite of its excellent management, very far from rivalling the cutting works of Amsterdam. Since the time of the celebrated Hermann, who cut diamonds in Paris in 1407, all the attempts made to localize this industry in France have been abortive. Mazarin installed sufficient Dutch lapidaries in Paris to cut those twelve splendid crown diamonds, known as the *Douze Mazarins*, but after his death the workshop was dispersed. In the latter half of the seventeenth century, there were at Paris seventy-five master diamond cutters, and in 1775 only seven were left. Calonne, whose name we often find among the promoters of the French industry, made a first effort, also fruitlessly; he established in the Faubourg Saint-Antoine a foreign diamond-cutter, Srabracq by name, who immediately prepared twenty-seven mills; but the troubles of the period doubtless scared the peaceable Dutchmen, who suddenly disappeared. Caire, who paid a visit to the abandoned workshops, found no other traces of Srabracq (or, according to Barbot, Schrabracq), save only his spectacles, and his carat-weights left out upon his desk, so precipitately had he fled.

The problem for the diamond-cutter to resolve, is how to raise round each small stone that opaque crust which shall cover its transparency, in such a way as to subtract as little matter as possible, and consequently as little as possible diminish the original weight; a first examination decides as to whether the stone shall be split up or cut as a brilliant. Cutting *en brillant* is reserved for stones sufficiently large to give room at the back for what they term a stock (*culasse*), and whose interior texture demands no sacrifice. The flat stones, or those which, though of some thickness, contain a fault in their interior which would mar their brilliancy, are handed over to the splitters (*fendeurs*).



SPLITTING.

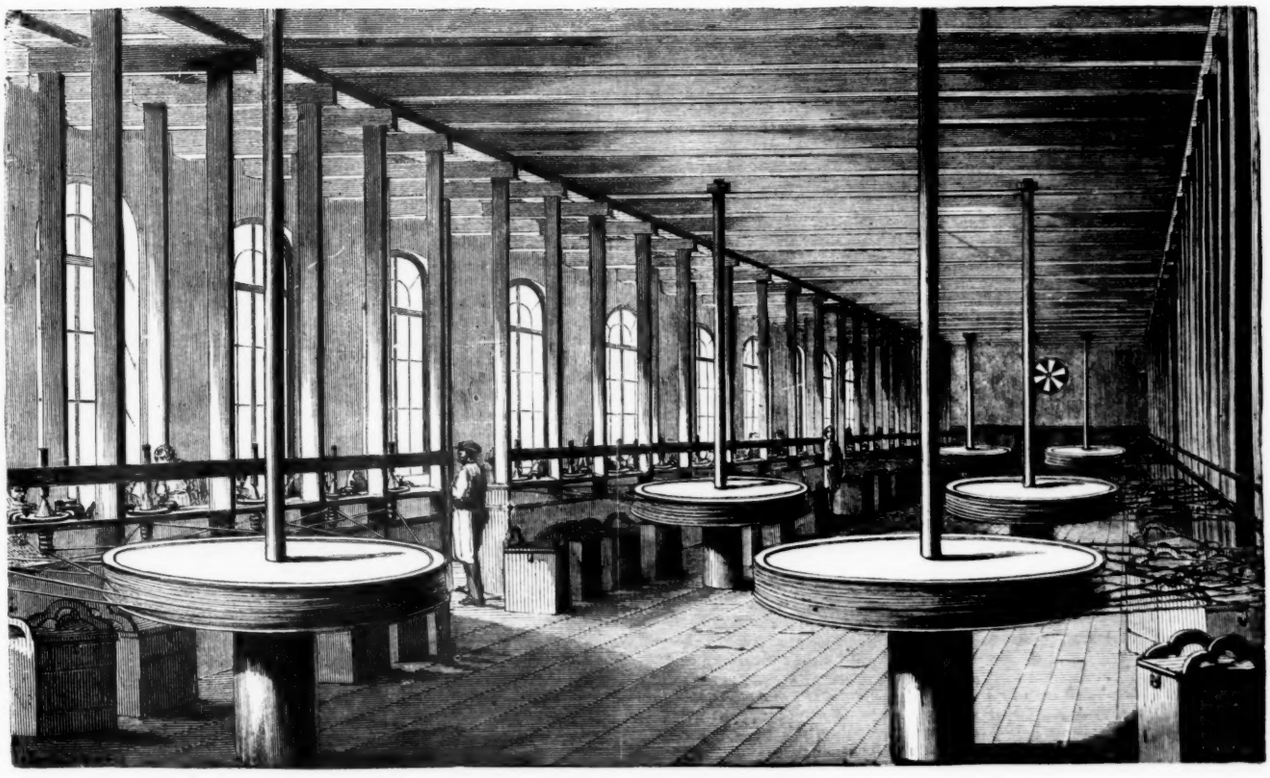
These men, seated in a little corner, have before each of them a box fifteen centimetres long by about ten wide, fitted interiorly with a double moveable bottom of brass, perforated with little holes. On each edge of the box a little peg is raised, destined to serve as a *point d'appui*, exactly as the rowlock-pegs against which the rowers lean their oars. The splitter, whose duty it is to cleave the diamond, commences operations by a careful examination. He seeks the place where the first entry should be made; for this stone, the hardness of which is proverbial, and which you might vainly strike with the sharpest steel, splits with extreme facility when you once find the key to its crystallization. The splitter then takes the stone, and leaving free the part he wishes to attack, encloses the rest in a mastic termed *cement*, composed of resin and powdered brick melted over a little gas lamp, which always stands before him. This mixture, as it cools, hardens almost instantaneously. The hardness is such that the stone imprisoned in the mastic cannot be detached by any effort, and you are obliged to re-melt the cement before the diamond can be again freed. The mastic, surrounded with a brass ring, is placed on a little stick fastened to the bottom of the ring, and increasing in size as it becomes more distant from the ring, so as to afford a good grip for the hand. The workman takes this stick, at the end of which is fixed the diamond that is to be split, in his left hand, and in the other hand a similar stick, in the cement of which is inserted a fragment of a diamond recently split. The edge of this fragment, still sharp and cutting, is the only substance in the world that can break the crust of the other diamond.

The workman rests the two necks of the two sticks one upon each of the brass pegs that rise on each side of his box: with the thumb of one hand he presses this neck against the peg, with the rest of his hand he see-saws the stick, using the peg as a lever, and rubbing with a force, now tenfold, the sharp edge upon the point he wishes to attack. At the end of some minutes, if he has carried out his measures properly, he has managed to make a notch in the shape of an open V. The diamond-powder resulting from this loss of substance is carefully collected in the little box, and falls through the sieve-like holes of the false bottom, the fragments of cement which are detached at the same time being caught and detained in the sieve. The workman then thrusts his stick into a hole bored in the centre of a block of lead affixed to the edge of the table. He takes a blade, more or less sharp, according to the size of the diamond at which he is working, places the blade in the prepared incision, gives it a little sharp blow with a small iron rod widening to a cone at each end, which serves him as a mallet. If the incision has been well made, this single blow suffices, and the stone is separated into two as if it were an almond. This first division, however, rarely suffices, for stones destined to be split have an irregular crystallization which require a series of cleavings before each fragment in itself is absolutely pure. Before the box fitted with pegs there is another box of the same form, but rather larger, in the cavity of which the stones that have to be treated are placed; on the left side there are five open holes corresponding to as many drawers, which serve to receive the small fragments, classed according to their dimensions. Other little morsels of the diamond, of which some are infinitely small, weighing one thousand to the carat, will all have to be cut, and it requires indeed a marvellous adroitness in the fingers, and an excellent sight, to handle, select, and examine these tiny fragments, each of which has, nevertheless, a certain value.

When the daylight darkens and the night has come, the workmen light the gas jets, and concentrate upon their sticks the brilliant light, passing first through huge bowls full of water, either pure and clear, or slightly tinted with green or blue. This work, which demands a sustained attention, is executed in the midst of a tranquil conversation, which contrasts strangely with the somewhat constrained air of the other diamond workers; it requires no strength, but much skill. From the workshop of the splitters the divided stones pass to the office, where they are examined and weighed; they are then distributed to the cutters, wrapped in little papers, on which are inscribed their number and their weight.

The workshop where what they call the rough hewing (*l'ébauchage*) takes place is situated at the top of the building, and this may be readily comprehended; through the nature of the ope-

THE DIAMOND-CUTTING WORKS ON THE AMSTEL.



THE POLISHING WORKSHOP.

POLISHING.

rations carried on there, it is not necessary to be installed near the source of the motive power, while it is absolutely indispensable to be as near the daylight as possible. Light is the essential agent, without which the diamond worker can do nothing. Thus the little table which fills the embrasure of each window is surrounded by workmen, pressing one against the other, and holding up to the light the extremity of the little stick, at the end of which, in a very hard mastic, the diamond is fixed, whether it has to be cut as a brilliant or as a rose.

The room, which is very large, is completely empty in the middle, while the windows are literally besieged with heads and hands. The cutter works with the same tools as the splitter, only his sticks are much larger, for he has need of great strength of hand to wear away, by rubbing one against the other, this pebble, whose hardness is proverbial; his hands are covered wlth gloves of solid leather, tight fitting to the skin, so as to maintain every articulation even in the struggle with the refractory stone. See-sawing the thickest part of the stick upon the ring of his little tub, he forms a lever, and by a movement of the wrist brings back the three last fingers pressed upon the broad part of the stick. These movements, which require a considerable muscular effort, appear to us to have no other equivalent in industry but in the hand of a dentist wrenching out a tooth. But it is not muscular strength only that the diamond cutter needs; he wants a vision keen enough to seize upon the slightest indications, the form, the colour, the meaning of every portion of the stone which is confided to him for cutting, for it is he alone who has to decide what form it shall have. It is necessary that he should judge how to preserve as much as possible of the original weight, how to dispose of the flaws so as to have them taken out by the polishers, and at the same time to direct the cutting and place the facets in such a manner that they shall refract the light under certain angles more favourable than others, and so produce those scintillations which they call the *flash* of the diamond (*les feux du diamant*). Before arriving at this result there are a thousand difficulties, known only to the diamond cutter. The first, and most important, is what they call finding the *grain* (*sens*) of the diamond. If they do not take the face according to its *grain*, they might rub on till countless centuries had rolled away, without scratching the stone; they have not only to consider which face should be attacked the first, but the relation it should have with all the other faces, and which all the faces should maintain between themselves; for if, after having finished sixty-three sides of a stone, there remained one whose grain they could not follow, the diamond would remain unpolished on that side, and would consequently lose a portion of its value.

The cutters also determine whether the diamond entrusted to them should be worked as a *brilliant*, or be sent to the splitters to be cleaved, and divided into fragments to be utilized as a *rose*. Although the highly-skilled employés in the office have already examined each stone, and decided beforehand the form it should receive, their judgment, sufficiently founded when the diamonds are defective or badly shaped, might be erroneous if they judged the stone too favourably. It is, indeed, almost impossible in examining a rough stone still covered with its crust to fathom the depth of the mass. The faults, being situated between the flakes, are much better seen by the cutter after he has commenced his work, and worn away a portion of the slightly opaque cuticle surrounding the diamond.

Generally the diamond-worker arranges matters so as to rub one against the other two stones of the same size and the same form. He thus makes a double work. When the stone is sufficiently thick to provide depth enough for the stock of the brilliant, the cutter commences by forming the surface which is to be the upper surface of the brilliant, then changing the position of the diamond in the mastic, he leaves exposed only that part on which at every change he marks the plan of a facet; he thus indicates the desired number of facets round the plane *table*, and the planned-out number of facets are directed in pyramid form so as to constitute the stock; but if a given number of facets has to be made, their inclination and their disposition are left solely to his judgment; the more weight he is able to leave on the stone, while cutting away all its flaws, the higher his scale of payment. It is easy to understand that this kind of work requires an absolute confidence in the workmen, as they could so

easily ruin a stone, and deprive it of a great part of its value; for this reason they give diamonds of upwards of four carats in weight only to the most experienced hands. The others, as far as five or six carats, are stored in little lots; that is to say, the clerks hand to each cutter, after having weighed it, this little lot containing some twenty stones, more or less, according to their size.

During work-hours the stones are deposited in a paper turned up at the edges like a chemist's envelope, but they are shut up every night in a little steel chest furnished with a padlock, of which the workman keeps the key. These little boxes, each bearing its number, are placed in a large safe, walled with thick iron, built of bricks strengthened with iron, and closed by a second iron door. Every morning the little coffers are taken from this safe and distributed among the workmen. When they finish their work they weigh how much each stone has lost in the case of the larger stones, but with the smaller stones they ascertain the loss on each lot; considering the quality of the stones they see whether the loss has been exaggerated, and the workman is paid inversely to this loss. They count the stones composing each lot, and if any be wanting the workman is fined to a heavier amount than the value of the lost stone. As a brilliant at five hundred to the carat, and more especially a rose at a thousand, are not large objects, it frequently happens that they drop through the fingers during the numerous manipulations to which they are submitted. Thereupon ensues a most careful search upon the ground and in the dust, which they sweep up with a brush with long bristles; we witnessed one of these searches, and we could see that the workmen considered the loss of this precious pebble as a matter of the gravest moment.

The workshop of the cutters, like all the other apartments in the establishment, is kept as neat as possible, so as to give as little chance as may be of losing the stones that fall upon the ground. Coming from their hands, the diamond has already the form it will preserve, but it is very dull; its principal faces are striated and rather greyish; now the facets have to be made, and the whole has to be polished. The diamond is too hard to be polished by any other substance than its own dust; this is the powder termed *égrisée* (diamond-dust), which has fallen into the little receptacle of the splitter or the cutter, and which, spread over a circular iron plate, can alone act upon the refractory surface. To be suitable for this purpose it ought to be reduced to an impalpable powder, without which it would scratch and wear away instead of polishing. It is crushed in a little steel mortar with a pestle of the same metal, which is battered violently down into the hollow. It is in this mortar, then, that they crush and reduce to powder either the cuttings and the uncutable diamonds, or the carbon or black diamond, which latter has no other merit than its hardness, no other utility than to provide polishing powder. This precious powder is worth as much as twelve francs the carat, that is to say, five thousand times twelve francs, or sixty thousand francs, the kilogramme; they are therefore not uselessly prodigal of its use.

Polishing is not, like cutting, executed with the hand; this latter operation, arduous as it is, demands a very much lesser force than does polishing; thus the polishing, as far back as we can go into the history of diamond cutting, has always been done with mechanical power.

M. Coster's workshop contains three rooms appropriated to polishing; the smallest is situated in the third storey, on the same floor as the splitting rooms and the offices, which are thus found in the very centre of the busiest work; the two others extend the whole length of the building. We give a view of one of these workshops. As in the cutters' room, the first thing that strikes the eye is the absence of all work-people from the middle of the apartment, kept carefully and scrupulously swept. Six columns of cast iron rise from the boards, corresponding directly through the planks with a direct transmission, admirably managed, though perfectly silent, from a steam-engine of forty-horse power. At about three feet from the ground these columns bear large cast-iron disks, measuring at least four feet four in diameter, and about eleven inches thick; from their centre springs an iron shank which crosses the ceiling, and gives motion to the disks on the upper story. The two level surfaces of these disks are polished and shining; the cylindrical surfaces are fluted to receive the driving bands of either gut or india-rubber or gutta-percha; the selection of these is left to the diamond cutter, who chooses after his own fancy, and according to the nature of his labour, the medium of transmission; for these driving bands transmit the circular motion of the large disks to the little grinding mills upon which the polishers execute their work. The difference in diameter causes these little mills to acquire a rotation of 2,500 revolutions a minute, when the large disks are turning with a relative slowness. The whole arrangements of the room, the whole construction of the building, the transmitting disks, the mills, one and all, are dominated by the sole thought of maintaining an absolute horizontality for the latter, and of increasing their speed of rotation.

The very edifice has been constructed according to this idea, and the solid walls are absolutely parallel one to the other, and at right angles to the flooring; then the disks are weighted and balanced, like the mills, with little bits of lead stuck on the lower side, turning in a perfectly horizontal plane, maintained by the spread of their cast-iron supports, which are at least seven centimetres in breadth. To assure the mills the same horizontality they have erected strong oaken supports, formed of uprights fixed to the floor and the ceiling, in the intervals of which the mills are placed. Crossing these uprights are three shelves of strong planking, not less massive, the middle one of which supports a kind of table, of about a metre in width. The middle of the centre plank is pierced with a round hole, through which passes the pivot of the mill; the upper and lower plank are also pierced with a square opening exactly opposite the other hole; in these two openings the diamond cutter places two extremely rigid sticks of *lignum vitæ*. He rests the inferior point of the pivot of his mill on the square extremity of the bit of wood below, and he lowers the bit of wood above till it meets the upper point of the pivot. It is these two pieces of wood that between them turn the pivot, the two points being opposite the *lignum vitæ*, which is slight enough to be broken easily, and yet stiff enough to prevent the points from giving at all out of the most absolute perpendicular. When the surface of the wood becomes too unequal, on account of the wearing caused by friction, the cutter with a big file smoothes the extremity, and continues time by time till the complete destruction of the quadrangular prisms, which he then easily replaces, thanks to the simplicity of their hafts.

The mill itself and its pivot have been established and slightly modified with the main idea in view of preserving horizontality in the rotation of the wheel, and thus accelerating its rapidity. The grinding mill is of iron, neither too hard nor too soft. The Indians, they say, use mills of very dense wood; according, however, to Tavernier, they are made of steel plates, and to the hardness of the metal he attributes the inferiority of Indian cutting. The Dutch mills are about forty centimetres in diameter, and scarcely one centimetre thick at the edges.

The upper part of the pivot is conical, and large enough at the base to easily guide the surface of the mill; it terminates in a jagged point which rests upon the upper *lignum vitæ* prism. The lower part of the pivot begins by a fluted portion round which is rolled the driving band connected with the disk, and terminates suddenly in a sharp cone so as also to rest with a jagged point upon the lower quadrangular prism. After all this the mill is balanced by the addition of melted lead stuck on the over-light places. When the driving band is fixed, and when the mill is set in motion it turns almost without a sound, and with such a regularity that it seems to be absolutely motionless.

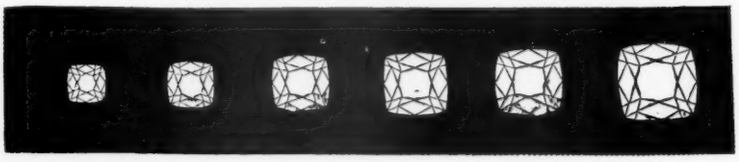
The appearance of a workshop full of polishers is rather strange. The room always seems to be empty; the disks in the centre of the apartment make a certain dull sound, and cause even a slight trembling. The mills on each row seem motionless in their rotation, and are generally hidden by a board which fastens the uprights of the building; one asks oneself where are the workmen. They have disappeared entirely behind the oaken uprights, in a long straight passage which runs along each side of the workshop, and which in its whole length has only three straight openings into the centre of the room; for room is precious, above all when the steam-boats come in bearing the lots of diamonds, and with them pressing orders. Every day the polisher passes between the section of the building which is reserved for him, and that half of a window-sill on which he has the right of depositing his tools. As he pays the proprietor of the workshop for this place, he does not stir from it until he leaves for the evening; his work permits him to eat and even to smoke without hindrance, and as long as he can utilize the power and the place for which he has paid he takes care not to lose a moment's time.

Formerly the diamond-workers laboured at home, and engaged women to turn a kind of winch which set the large wheel in motion. The masters paid him for his labour by the piece, and he paid the women. At present they have put at his disposal motive power much more regular and much more economical. For these as before he has to disburse, and he is still paid by results. He has therefore a great interest in utilizing every moment of his time.

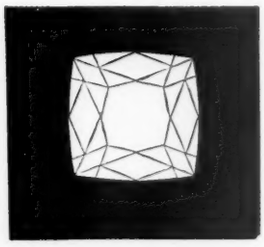
The polishers, like the cutters, receive the large stones singly, and the small ones in lots, more or less numerous. The diamonds, roses or brilliants, have their facets indicated, it remains only to finish them and to polish; for that it is necessary as in the rough stone, and as in splitting, to fix them in a cement which can be softened sufficiently for the insertion of the stone, and can be sufficiently hardened to retain it firmly in spite of the wrenching force with which the mill acts. Here the cement is

not resinous but metallic—an amalgam of lead and pewter, contained in a little brass capsule, to which a projection gives an exact resemblance to an acorn beginning to develope. This is placed upon a solid handle, about ten centimetres long.

When they wish to fix a diamond in the metallic cement, they place the copper shell, which contains the amalgam, upon a brazier filled with wood-charcoal, well carbonized and giving out no trace of smoke. But there is no need for intense heat, or to altogether melt the amalgam ; it is sufficient to soften it, so that the stone can be inserted, leaving free that facet which is to be the first polished. The polisher uses pincers for this operation, which he concludes by taking the shell from the brazier and put-

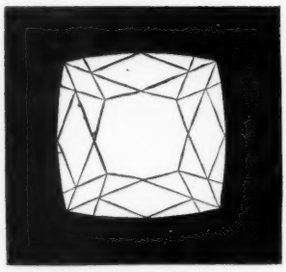


1 carat. 2 carats. 3 carats. 4 carats. 5 carats. 10 carats.



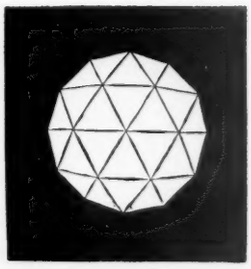
50 carats.

One kilogramme contains 4,875 carats.

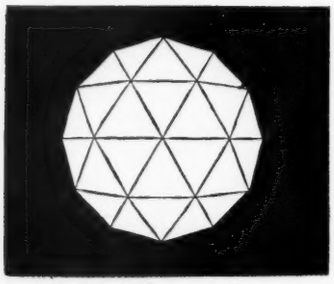


100 carats.

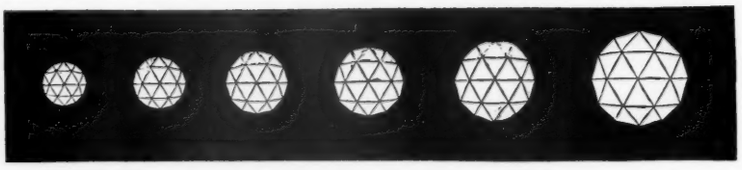
BRILLIANTS.



50 carats.



100 carats.



1 carat. 2 carats. 3 carats. 4 carats. 5 carats. 10 carats.

ROSES.

DIMENSIONS OF DIAMONDS, ACCORDING TO CAIRE.

ting it into a kind of large wooden egg-cup, where the handle has been inserted, and which holds the shell, containing the amalgam and the stone, very firmly. With the aid of a small pair of nippers, and above all, of his fingers, of which he makes good use, the polisher gives the softened metal the form of a cone, terminated by the stone ; he then withdraws the shell from the wooden support, and allows it to cool.

Without witnessing it we cannot imagine to ourselves the prodigious address with which the polishers turn and re-turn their stones, often of an extraordinary smallness. Thus, they polish roses up to a thousand to the carat, and give them twenty-six facets ; they must then six-and-twenty times fasten in the amalgam, a body certainly no bigger than a pin's head ; that, too, without letting it slip, yet leaving free only one face to be polished, the rest being enveloped and held by the metal ; they truly need good eyes, were it only to distinguish the facets, and

it is merely through long practice that they can see whether a facet be polished or not, especially in the smaller sizes. As for the large stones, there is another kind of difficulty; the facets being larger, it is necessary that the polisher (for in this case the cutter does not intervene) should not deceive himself about the grain, or what Tavernier calls the *chemin* of the diamond; he must settle the direction in which he will present his stone to the mill; without that he would in vain spend his time and waste his powder, and the more he scratched on his mill the sooner would it be unfit for service. To see clearly at his work, the diamond worker requires much light; and it is for this reason that the polisher sits with his shoulder leaning against the window-sill, receiving on the point of his shell all the light coming through the opening, and enabling him to see at each instant how the operation is progressing. The rubbing is not worked with the hand, they use a pair of great heavy iron pincers, the jaws of which hold the handle of the capsule; these pincers have a solid base weighted by lead, and they load them with ingots more or less heavy, according to the size of the stone, and the difficulties of polishing. Iron bolts are fixed in the table round the mill, and serve as rests for the pincers in the direction of the rotary movement; the polisher generally conducts two or three

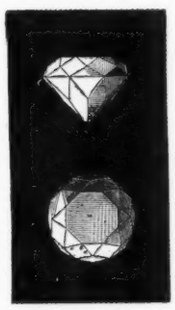


Fig. 1.

Fig. 2.

Fig. 3.

operations at once, according to his skill, and often he abandons the pincers to themselves, while he goes to melt the amalgam or take out a stone, on one of the facets being polished.

During the whole time of grinding he frequently withdraws the diamond from the mill to reassure himself that he has not been deceived as to the grain of the stone; he watches also to see that the surface of the mill is always smeared with a light sprinkling of very fine diamond-dust, moistened with oil, which he supplies parsimoniously drop by drop. To make the work go well it is essential that the grinding surface should lightly be striated in rays, pointing obliquely from the centre to the circumference; these *striæ* retain the diamond-powder which the centrifugal force would throw off. After some little time the diamond cuts furrows so deep that they have to be removed with a file, and after some months the plate of the mill, now worn and wasted, is no longer to be repaired, and has to be set on one side.

Whether they wish to obtain brilliants or roses, the operations of cutting and polishing are identical, but the number and the disposition of the facets differ extremely. Thus, the brilliant (fig. 1) is obtained by first determining the centre and then surrounding it with eight cut panels, divided finally into four facets each; this is the visible portion of the stone. Underneath are cut eight panels similarly divided into four each, and these constitute the stock. The rose (fig. 2), level behind, forms a dome, more or less elevated, of twenty-four facets. A good rose of fine water is of a value not equal to a brilliant of the same weight and similar purity, but very superior to a flawed and badly-coloured brilliant. Various fantastic cuttings, without speaking of the star indicated by Caire (fig. 3), are still employed, though very rarely, when the shape of the stone obliges the diamond-worker to deviate from regularity. The roses termed *d'Anvers* have only six facets.

In M. Coster's establishment there is no diamond engraver; M. Bordincx, of Antwerp, is at present the only person in Europe who knows the art of engraving this rebellious stone, and even he cannot polish the engraved lines, which remain grey and tarnished.

THE MEXICAN METHOD OF MAKING HARD LIME FLOORS.[1]

By Gen. Theo. G. Ellis, C. E.

Some years since the writer had occasion to visit Northern Mexico, to examine and work some silver mines; and while passing through the Mexican villages, noticed the exceedingly hard and polished lime floors and roofs of the houses.

In the village of Salinas, where our party remained some three weeks, the horses passed daily through the house into the inner courtyard over one of these floors without leaving an indentation, or injuring it in any way. Some time after, having occasion to construct some buildings at La Yguana mines, an attempt was made to imitate these floors and roofs. Attributing the peculiar hardness and smoothness of the floors to the inherent good qualities of the lime used, no inquiries were made as to the Mexican method of working. A good quality of limestone was selected and calcined in the ordinary way. Shortly after burning it was slaked to a dry powder, and afterwards used as required. A floor was laid with a foundation of about three inches of broken stone, over which was evenly spread about two inches of mortar, formed of two parts of clean sharp sand and one of lime. The lime was "fat," swelled greatly in slaking, and was not at all hydraulic.

The floor, made as above, was a total failure. At the end of four weeks the leg of a chair would indent it. As soon as the surface was damaged it began to crumble, and soon broke up. It would probably have been about as hard as our ordinary lime mortar if allowed to set a sufficient length of time before being used.

Knowing that the Mexicans used the same materials with better success, their superior skill was called into requisition to lay all the remaining floors and the roof of the same building. They used the same sort of lime and sand in about the same proportions, and upon the same kind of foundation. The result was a floor as hard and smooth as a piece of polished marble, that a horse could trot upon without injury.

A brief account of the method of making these floors may not be uninteresting.

The limestone used was a hard, compact blue material, in some places sufficiently hard to strike fire on the drills used in running a drift through it for mining purposes. It often contains iron pyrites in small proportion. This was calcined in kilns cut out of a very soft limestone, that likewise is found in that section of country, and which, on account of its whiteness and softness, is called "cal leche." I believe it is never used for making lime by the Mexicans.

After calcination the lime was removed from the kilns and slaked as soon as cool. Some of it was used within a day or two, and some remained a month or more in barrels. All the work made with it seemed to be equally good.

In making the floors, a layer of broken limestone, three or four inches thick, was first laid evenly over the surface of the ground, the stone being about the usual size for macadamizing roads; over this a mortar of about two parts of sand to one of lime was carefully and evenly spread to the thickness of one and a-half to two inches; this was allowed to remain for about twenty-four hours, or until the surface had become quite dry. It would probably take longer in this climate, where the air possesses a greater amount of moisture than in Mexico.

The floor was then thoroughly pounded all over with a tool composed of a block of wood about a foot square and three inches thick, having a handle rising from the middle, so that a man could stand while using it. The whole surface was beaten over

[1] From the American Society of Civil Engineers.

with this ram until it was again as soft and moist as when first laid. This operation of ramming brought the water in the mortar to the surface so as to form a layer of semi-fluid substance on top.

The floor was again allowed to dry, and again beaten over each day for about a week, when the operation brought only a slight amount of moisture to the surface.

Immediately after the last pounding the whole surface was powdered with a thin layer of red ochre, evenly sifted on, and then polished as follows :

A smooth, nearly flat, water-worn stone, a little larger than the fist, was selected from the bed of the stream which ran through the place, and with this the whole floor was laboriously gone over, rubbing down and leaving the surface of the lime as smooth as a piece of polished stone ; the red of the ochre rendering it of a rich brown colour.

In less than a week the floors made in this way were sufficiently hard to bear the weight of a horse without indentation.

Roofs were made in the same manner without the colouring matter, which was added only to give the floors a better tint than the grey of the mortar. These roofs were perfectly water-proof, and were unaffected by sun or rain.

In the city of Monterey, sidewalks in the principal streets are made in the same manner, and some of them have lasted for years, wearing through like a block of stone.

The great durability and strength of these floors and roofs is entirely owing to the pounding operation above described, as the same materials were tried in the ordinary way without success.

The writer has not had occasion to make use of this process in this climate, but gives a description, hoping that it may be of value to others who may have occasion to lay floors of lime in architectural or engineering works. He has never heard of this method being employed in this country ; although it seems singular that it should be used so generally by a neighbouring nation, and be wholly unknown to our builders.

Appendix.

The following correspondence, growing out of the above, is here printed :

From Estevan A. Fuertes, C. E., Member of the Society.

A paper read before the society, upon a Mexican method of consolidating mortars, described as of extreme hardness, suggested to my mind that, perhaps, its author might be mistaken in attributing its main durability and hardness to the slow system of consolidating the road-bed and its cover.

My doubts have grown out of the circumstance that the author says (without seeming to attach much importance to the fact) that ochre or a similar pigment was mixed with the mortar.

I think that the colouring matter, believed to be of secondary importance, is the main ingredient which determines the superiority of the cement described ; and instead of its being ochre, it was under-burnt brickdust.

If I am not the one who is mistaken, the consideration of this subject will bring up for discussion the method of obtaining a cheap and superior cement that, I believe, has not been used much in this country.

The hydraulic engineer has much need of studying the causes which induce the "setting of mortars," because it is almost certain that the resistance of such materials as bricks, limes, and cements, depends upon their conditions of crystallization.

I am aware of only two methods of hardening the silicates usually employed in hydraulic works, viz. the gradual chemical change (crystallization in the slow, humid way, as in submerged foundations, etc.), and the quick vitrification under the influence of intense heat, as employed in brick-making.

It is notorious that under-burnt brick resists very badly the influence of atmospheric wear, especially near salt water. I have crumbled in my hand an under-burnt brick, one year after its exposure to the sea spray, and gunpowder was manufactured from the nitrate of potassa formed upon its porous substance ; but the same clay burned with chalk, making a double salt of carbonate of lime and silicate of alumina, or rather a sub-crystalline double silicate of lime and alumina, after being ground, made a cement susceptible of receiving a splendid lustre, and withstood the action of the spray and of the waves without apparent change.

Both the limestone and the brick had been used separately as building material in a burying ground near the sea shore, where the experiments were conducted in 1861. Eighteen months of exposure for the stone and twelve months for the brick were sufficient to render both materials useless ; but when burnt, ground, and mixed, they stood much better than the finest and distinctly crystalline marbles.

At the end of three years, or more than the sum of the times of durability of each material, I left the place where the experiments were made, and then the cement had not changed where the surface had been left rough, nor tarnished where it had been polished.

A cement called "revocado" by Spanish engineers is made by mixing in several proportions fat limes with sand and under-burnt brickdust. The usual proportions are measured by equal volumes of the three materials ; but when the cement is to be used for stopping roof leaks, cementing cellars, or where blows upon the cement are not anticipated, the proportion of sand is greatly diminished, and even suppressed altogether.

The Spanish learned the compounding of this cement from the Biscayans probably ; and I doubt if the Romans had anything to do with its introduction in Spain, because the ruins of ancient water channels with "revocado" exist in the Basque provinces, where neither Romans nor Moors ever penetrated. The Biscayans, in their turn, are the most ancient people with whom we are acquainted, it being probable they they preceded the Phœnicians.

I have seen Spanish "revocado" in Mexico, and it is natural to suppose that the Spaniards introduced the art in that country during the conquest.

Now, may it not be possible that the ochre referred to by Gen. Ellis is only powdered brick, used to make the excellent and hard "revocado?"

The description given of the method of consolidating the mortar, etc., and even the employment of wooden compressors, explain accurately the process still followed in Spanish countries to form the floorings of plazas, public walks, etc.

In many cases, immediately before the cement becomes set, its surface is polished with a smooth cobble stone until it acquires a high and lasting lustre.

From Gen. Ellis, in reply to the above.

Having read the remarks of Mr. Fuertes upon my recent paper relating to hard lime floors, I apprehend that he did not give sufficient attention to the process therein described.

In no case was the red pigment mixed with the lime and sand, as he supposes, but was solely used for a surface colouring after the hardening process was completed. Roofs and sidewalks of equal hardness were also made by the same process of successive poundings without the colouring matter, and finished by polishing in the same manner as the coloured floors.

The pigment used upon the floors was not brickdust, but a red earth found in the vicinity, probably a fine clay coloured with sesquioxide of iron. Bricks were not used in that part of the country, "adobes" taking their place in building.

It will thus be seen that the material of which the described floors and roofs were made was not the same as the "revocado" used in Spain and Southern Mexico, described by Mr. Fuertes. Is not the term *revocado* essentially the same in meaning as the more common Castilian word *revoque*, one being the participle and the other the noun corresponding to the Spanish verb *revocar*, the nearest English equivalent to which, in an engineering sense, is to *rough-cast?* This implies an admixture of coarse material in the mortar. "Revoque" was known to the Romans as "*parietis linimentum*."

Mr. Fuertes is, I think, in error when he attributes any rapidity of setting, great hardness when set, or improved hydraulic qualities, to the mixture of burnt or under-burnt brick in any proportions with lime. The experiments of Smeaton show conclusively that the only gain is the slight amount of moisture that the brick will absorb from the lime and favour its *drying*.

The only way in which hydraulic properties can be given to a compound of silicate of alumina and carbonate of lime is by burning them together after being mixed, as in the production of artificial cement. This is exactly what was done in the case Mr. Fuertes recounts ; clay and chalk were burned together, and if in proper proportions would form an excellent artificial cement. It is not remarkable that neither should be a good building material by itself.

If the "revocado" of the Spanish possesses any quick-setting or hydraulic qualities, it is probably not owing to the admixture of common brick, but to some qualities of the lime, or perhaps what Mr. Fuertes has taken to be brick was artificial "trass," formerly much used, which was burned like brick, and when added to mortar, gave it hydraulic properties.

I think it highly probable that the process of pounding ordinary lime mortar for many successive days in order to give it hardness, and afterwards polishing the surface, originally came from Spain to Mexico, and is probably an ancient practice. The only matter of surprise is that it has not become more generally known and used.

Note by the Printing Committee of the "Journal of the Franklin Institute."

Is this "pounding process" of the Mexicans anything more than a simple yet effectual method of freeing the mortar of its

surplus water, and thereby insuring a condition in which the lime can pass to a crystalline carbonate, at the same time compacting the whole mass into the best possible state?—*Vide* "Transactions" of this society, No. x.

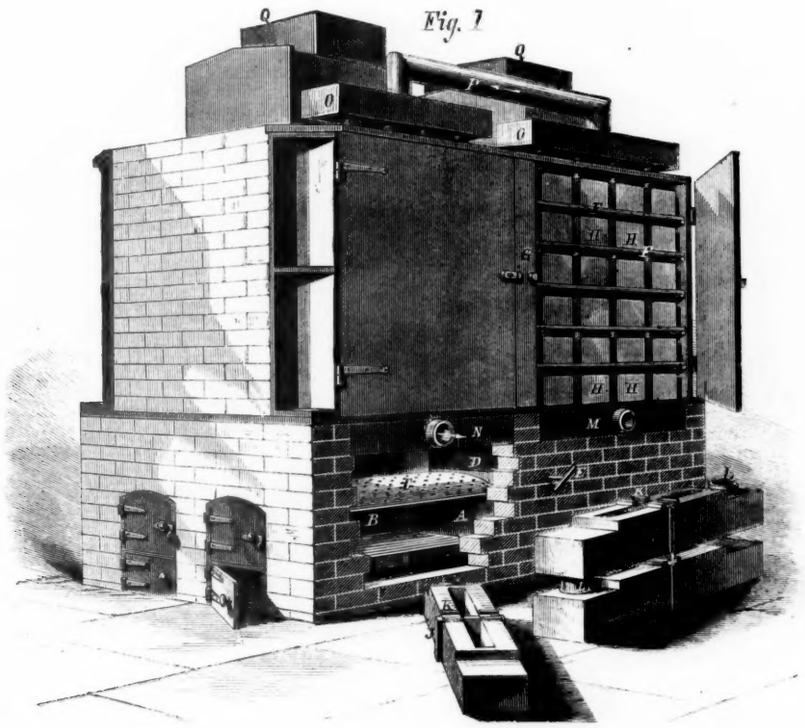
IMPROVED HOT-BLAST OVEN.

THE invention herewith illustrated is an oven for heating the air supplied to blast-furnaces. The various portions are constructed with a small weight of metal, and in such a manner as to provide against lateral and vertical deflection under a high degree of heat. By suitable means the gases which do not support combustion are allowed to escape, so that the oven may be heated by stone-coal or similar fuel.

Fig. 1 shows the device, with parts broken away to exhibit the interior arrangements. Fig. 2 is a vertical, and fig. 3 a horizontal section of a heating tube. The base of the oven is divided transversely by the partition *a*, and longitudinally by the partition *b*, into compartments. In the two chambers in front of partition *a* are the fire-grates and ash-pits, as shown through the broken-away wall, immediately above which are perforated metal arches, one of which is represented at *c*. In the partition *a*, are two openings, as at *d*, provided with dampers and regulated by a lever, *e*, outside of the side wall. The object of these orifices is to furnish a means of escape for the gases into the empty compartments in rear of the base.

The upper portion of the oven consists of four metal columns at the corners, which rest upon frame-plates. On these columns are cleats, which support the ends of the bars or shelves, *f*, on

Fig. 1



which the heating-pipes rest. The other extremities of the bars are held up by similar cleats on the middle column *g*. Each heating-pipe is divided into two narrow branches, which connect at the ends in single chambers *i*. This arrangement is shown in the pipes lying beside the oven, fig. 1, and also in the sectional views, figs. 2 and 3. A vertical bar or stay is placed at the middle and between the two branches, so as to keep them firmly in position. The ribs *j*, on adjoining tubes, fit closely together so that one pipe affords lateral support to the other. At *k*, on the upper side of the pipe, are fastened cleats which form a groove or recess running across the top of each tier of pipes when placed in position on the bars. In this groove is shoved a T-shaped rail, the upper edge of which comes in contact with the lower sides of the next tier of pipes above, thus affording a firm support and preventing vertical deflection.

The inner surfaces of the pipes are corrugated, as in fig. 3, thus giving a greater heating space and increasing the lateral strength. At the upper side of one end of each pipe is placed a vertical tube *l*, which connects with the under side of the similar end of the pipe next above. The pipes in position are shown at *h*, fig. 1, and are contained in the two chambers formed by the extension of the partition *a*, to the top of the oven.

M and *n* are cast-iron chests secured under the frame-plate. The opening in *m* serves to admit the air which passes from the chest up through one set of heating-pipes and thence to one of the metal boxes *o*. Passing through the connecting tube, *p*, the blast descends through the other system of pipes, and thence into the box *n*, through the opening, in which it is discharged in a heated condition to the tweer. The arch of the oven is of

Fig. 2

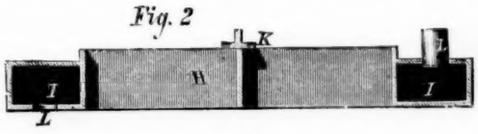
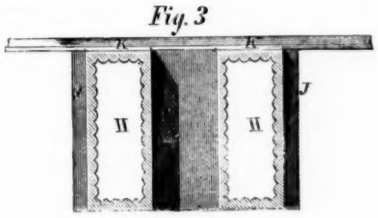


Fig. 3



fire-brick with openings in the centre, to allow the passage of smoke, &c., out of the chimney *q q*.

The advantages claimed for this device may be briefly stated as follows :—

The peculiar shape of the heating metal which affords a large area of heating surface in proportion to the number of joints and weight of iron; the construction of the interior of the heating-pipes so that some portion of every cubic inch of air within them is in contact with the heated metal; the facility with which a change of pipes may be effected without stopping the furnace and cooling down; the arrangement for carrying away impure gases and supplying the furnace with pure air, so that the latter can at all times be kept at regular work without change of burden; corrugating the surface of the heating metal, thereby increasing its facility for absorbing heat; the shape of the heating-pipes as insuring durability at a high temperature.

Patented Sept. 3, 1872. For further information address the inventor, Mr. Jesse Young, Trigg Furnace, Trigg County, Ky.

THE DON OIL.

A RELIABLE and cheap lubricant is one of the first necessities of mechanical engineering, and the yearly and rapid increase in the manufacture and employment of every kind of machinery tends in a great measure to keep up the prices of all lubricants, and the cost of a lubricant forms a heavy item in the bills of steam companies, manufacturers, and railway companies.

The oil whose title heads this paragraph is an American oil, somewhat resembling Virginia oil. Messrs. Duncan Bros., of 2, Blomfield Street, Finsbury, London, are the sole manufacturers and importers of this oil. They lately invited our attention to it, and they have laid so many testimonials to the efficacy of the oil before us that we have no room to doubt its excellence; for some of the testimonials are from men of high standing in mechanical engineering, and who are large consumers of lubricants.

The Don oil is of a dark brown colour, a characteristic which, while it in no way affects the quality of the lubricant, raises a prejudice against it amongst workmen; and its low price, being 40 per cent. cheaper than Gallipoli or lard oil, makes it, on the other hand, a much better article for employment by steam companies, railway managers, and mill-owners than the more expensive oils they now use. One of the great advantages of this Don oil is that it does not thicken or become gummy, a serious defect of some oils. Messrs. Duncan first introduced it at Liverpool about four years ago, but the parties who then ordered it were disappointed with its colour, they expecting it to resemble olive or colza oil; and this, along with the opposition to its use exerted by the working men, who also disliked it for its colour, militated much against its introduction. A saving of 40 per cent., however, is a powerful stimulus, and those gentlemen who first tried it, persisted, and the oil is, we are pleased to find, outliving its first difficulties, and the manufacturers are now securing numerous orders. It is fair to them to say that their list of customers contains the names of the Wigan Coal and Iron Company, the Brecon and Merthyr Railway Company, and Messrs. Dubs and Co., Glasgow Locomotive Works. The Government too, we understand, are of late using it to some extent. Messrs. Duncan, we believe, will supply trial casks, to be returned if the oil is not satisfactory, charge being made only for the quantity used. We feel pleasure in inviting the attention of our readers to this economical lubricant.

CASTING IRON UNDER COMPRESSION.

THE great increase in the application of the base metals to ornamental purposes observable of late years has so far taxed the skill of the founder and moulder as to incite inventors to devise improvements on the ordinary methods of making these ornamental castings. These castings are of two classes: the one and coarser sort is employed on the exteriors of almost all buildings, however humble, as ornaments for eaves and ridges, as well as for window rails, entrance gates, and other similar purposes; the second and finer sort, largely dealt in in Birmingham and Glasgow, and applicable to internal uses and decoration. Castings employed as external ornaments can, as a rule, be made clean and sharp enough for use without any subsequent chasing, but this is not the case as regards the finer and more elaborate ornaments decorating the inside of a building. Then again there are the numerous articles, used heretofore only in the houses of the wealthy, such as caskets, salvers, clock-cases, ink-stands, &c., which, under the old methods of casting, were useless until chased by high class and skilled artificers, this latter process immensely enhancing the cost of production—so that this class of ornaments has been hitherto quite beyond the reach of any but the wealthier classes.

The need for some method of casting metals which would produce better and cleaner castings, castings that would not need any subsequent labour expended on them beyond "fettling" and washing, was felt strongly by Mr. J. J. C. Smith (Smith Bros., Philadelphia, U. S.), and some two years ago he secured a patent for the process we are about to describe. After the securing of the first patent the matter was not pushed in this country or presented to the public until within the last few months. All who behold the process, however, cannot but feel admiration for its simplicity, ingenuity, and the perfection of the results secured by it.

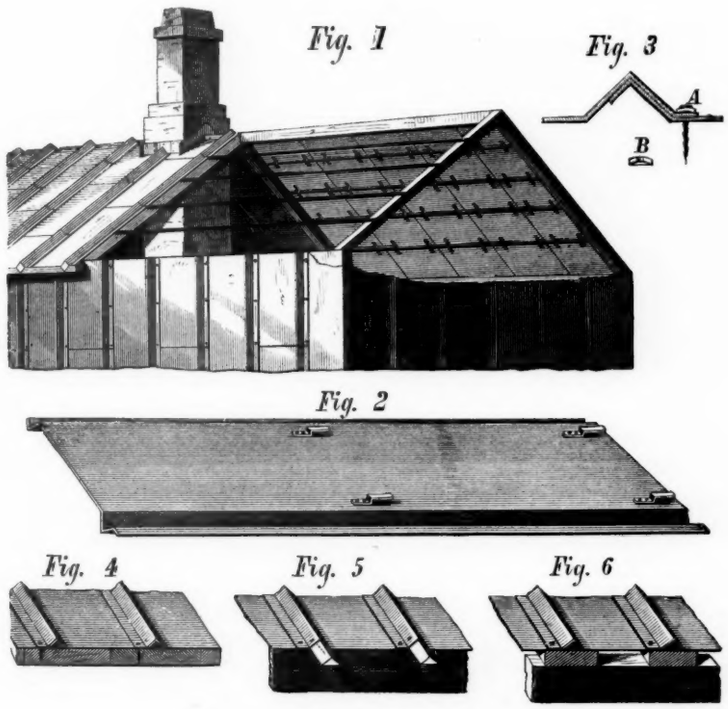
The principle of the process is contained in the casting of the metal while subject to a considerable and continuous pressure; but besides this leading point, there are one or two subordinate features about the process in the way of improvements in the preparation of the moulds; because the mere flow of molten metal under pressure is not of itself enough to secure a casting so free from blemish as to need no subsequent tool-cutting; and between the perfection of the moulds and the way in which the liquid metal is, as it were, squeezed into the minutest interstices of the mould, castings are produced by Mr. Smith's process so perfect and beautiful in each crevice of the most elaborate arabesque, as to guarantee the reproduction and multiplication of any object, however delicate the pattern, in a perfect *fac-simile* and able to stand the test of the most minute examination and inspection, even under the microscope.

Taking the first or moulding stage, we will suppose that the article to be reproduced is a fine medallion, one of Mr. Wyon's masterpieces, having, suppose, a plain reverse. It is laid face upwards upon a thick, smooth metal plate, fitted with certain stops to retain the medallion in position. The latter is then coated over with a creamy mixture of kaolin, or China clay, and fine sand flour, mixed with oil, the whole resembling in consistency very thick paint; this is laid on with a soft brush. The plate and medallion are then placed in the bottom of a flask of great strength, made of iron or gun-metal. The very finest description of moulding sand is sprinkled over the medallion, first by hand, and then the flask is filled up about water measure with the same. This being done, and the sand being well tamped round the sides with a wooden dolly, the flask is pushed beneath a frame much resembling a very large letter-copying press; the screw is turned by two men moving a long iron cross handle, and a plate precisely fitting the interior of the flask is forced down on the sand;—in fact, this part of the process is identical with what is known as the semi-plastic method of making bricks. The flask is then withdrawn and the sides opened, then the plate and sand, now nearly as hard as a flooring tile, are removed, and reversed upon a surface table, and the plate lifted off. The medallion is gently heated by a gas blowpipe; this expands it slightly, still further forcing its impression into the sand; then on cooling down it contracts, becomes loose, and is easily lifted out. The fine clay slip makes a beautiful, smooth, glossy surface-lining to the mould. The mould is further hardened by baking, and at the time it is ready to receive the metal it forms a most faithful impression of the object to be reproduced. As a matter of course any description of mould can be made, either single or in halves, and with or without a core, as required; more than a single casting also may be comprised within one mould block, a separate "gate" being provided for each. Each mould has one large orifice going quite through it from side to side, the side gate to the matrix opening from it.

When a number of these moulds are complete they are ranged in order within a proper casting case and compressed by a screw; the holes of all the moulds correspond and form a pipe or tube terminating at the point where the metal is to enter. The orifice in the casting-case is fitted with a circular clay collared nozzle, which nozzle is fitted with a clay plug which fits it tightly. A horizontal iron cylinder communicates with this nozzle, and within the cylinder works a piston and rod, the rod passing out of the end of the cylinder most remote from the moulds. In the upper side of the end of the cylinder farthest from the moulds is a hole, surmounted by a hopper. As the molten metal would at once chill solid as a ring, where it encountered the cold metal of the cylinder, the latter is coated inside with a "fettling" of some refractory substance, which is applied with a brush while in a semi-fluid state. The *modus operandi* of casting is simply as follows:—The piston being drawn back, the molten metal is poured into the cylinder; the piston is then urged forwards, by means of power applied behind, to the piston-

rod. As the piston—which is simply a solid disc fitting the cylinder itself precisely—advances, it scrapes off the lining of the latter, and this lining curling inwards effectually packs the piston and prevents the escape of the metal by leakage. For a time the clay plug in the nozzle resists the pressure of the iron urged on by the piston; it, however, is at last forced in, and the metal, impelled on by the piston, is forced into the minutest cranny of the moulds. A great and advantageous feature of the process too is the total exclusion of the air during the passage of the iron into the moulds. This, from the accuracy in making the moulds by the aid of machinery, and the subsequent forcing of the metal into them while the metal is fluid, gives as a result castings perfectly homogenous and free from air blows; and the design of the matrix is reproduced on the metal so perfectly that no subsequent tool-chasing is requisite, because the original itself, perhaps a perfect example of the chaser's art, is reproduced in perfect *fac simile*. We may perhaps add that Mr. Robert Mallet, M.I.C.E., F.R.S., Mr. H. Gardner, C.E., and many other gentlemen whose opinions on such subjects are valuable, have from time to time examined and reported on the process in a tone of uniform approval.

It will be observed by our readers that no complex or difficult operations are involved in this process of casting; the work is of a nature so simple, and as a rule so light, that women, boys, and girls can perform it quite as well as men, and at the same time it supplies a means of reproducing in infinite numbers, all the gems of carving, modelling, and chasing that are in existence, thus largely contributing to the promotion of a more purified taste throughout the world by bringing objects of real beauty within the reach of the most humble household. There is no limit either as to the nature of metal, for any metal, from cast-iron to gold, may be employed. Any of our readers who feel curious in this matter can go to Ludgate Circus, London, where Mr. Smith has offices, and he will show to any visitor numerous examples of castings of great beauty made by his process.



BELT'S IMPROVED SHEET-IRON ROOFING.

IMPROVED SHEET-IRON ROOFING.

THE "Scientific American" reports—Our engravings illustrate a good form of sheet-iron roofing, which was patented by Mr. W. S. Belt, of Cincinnati, Ohio, Aug. 8, 1871.

Fig. 1 represents the roofing partly applied to the roof and sides of a building. In fig. 2 is shown the under side of one of the iron sheets of which it is composed. It will be observed that the sheet is triangularly crimped at its sides in such a way as to allow the crimped portion of one sheet to overlie the crimp of another (in the manner shown in fig. 3), and that the lower side is provided with fastenings which are riveted to the plate. The overlying crimp has a perforated flange, through which two adjacent sheets may be nailed to the sheathing or rafters of the roof, as shown at A, fig. 3. It can readily be seen that, in thus employing the roofing, each sheet is fastened by both of its sides to the supports. The nail used is barbed, and as the fibres of the wood into which it is driven soon resume the position from which they are displaced, a very firm hold is taken by it. A lead washer, as at B, is placed between the nail and the plate, and by its use any unevenness of surface is accommodated and an air and water-tight joint formed on driving the head of the nail home into the lead. The sheets are eight feet long and two feet wide between centres of crimps, and, as manufactured, are coated on both sides with paint.

Fig. 4 represents the application of the sheets to a sheathed roof, in which case rough boards of an even thickness are all that is necessary for the sheathing. Fig. 5 shows the mode of applying the roofing to purlins where no sheathing is employed. In this case the purlins may be placed any distance less than eight feet apart, and triangular strips of wood are nailed to, and at right angles with, them, two feet apart between centres, so as to fit under the crimps and support the sheets. Or boards three inches wide may be nailed to the purlins, and the sheets applied to them in a similar manner to that shown in fig. 6, which represents the mode of attaching the roofing when rafters without sheathing are to be covered. In the latter case, strips of boards are let in, on a level with the upper surface of the rafters, for the ends and centres of the sheets to rest upon. The triangular strip may be placed under the crimp in any case if desired. The ends of the sheets are joined by overlapping them, or by bending them so as to form a lock joint; which, as they are well annealed, can readily be done. The sheets are also easily made to conform to the angles of roofs of either ordinary or peculiar form, so as to make perfectly tight joints and fully preserve the effective character of the roofing. It is applied

with such facility, aided by the inventor's directions, as to require no skilled workmen to put it on.

Mr. Belt has also devised a combination iron frame to support his roofing, by the use of which cost is lessened and its fireproof qualities heightened. Its construction will be understood from fig. 1, where the rafters are seen to sustain bands stretched between them. These bands are made of strap-iron, and are placed 46¼ inches apart. To these bands the fastenings on the under side of the sheets before alluded to, seen in fig. 2, are hooked, and the roofing thereby secured in position as seen in that portion of fig. 1 which shows the under side of the roof. By using iron for the rafters a fireproof roof is made.

Many advantages are claimed by the inventor for this mode of roofing. He says that the crimp gives so much stiffness to the sheet, it is enabled to sustain itself and also considerable weight in the centre when supported only by its ends. There is, consequently, no liability to "bag."

Its fastenings are so secure as to prevent any wind affecting it, and, at the same time, if damaged, it can easily be taken out and replaced. The entire roof can be taken off one building and put on another without damage and at trifling expense, for which reason it is considered admirably adapted for temporary buildings. In all these respects it is superior to the plain sheet metal roofing, and it is claimed to excel the corrugated; while the same weight of metal in the crimped form covers 20 per cent. more surface than if corrugated. In roofing warehouses and small buildings on this plan, from two-thirds to three-quarters of the wood usually employed could be dispensed with.

Further information can be obtained by addressing the inventor at 56 and 58, East Third-street, Cincinnati, Ohio.

PATENT GOVERNOR & GOVERNOR-VALVE.—In all prime-movers employed to actuate machinery for spinning, grinding grain, and for many other purposes, uniformity of speed is a matter of the first importance, consequently a good and sensitive governor for steam-engines is sure to receive attention. We have now before us the drawings and description of Allen's patent governor and valve for stationary, marine, and portable engines.

The description of the governor is as follows. A paddle-wheel is caused to rotate within a cylinder filled about two-thirds with oil. The cylinder is corrugated, and has on its inner periphery certain projecting ribs. The paddle-wheel is mounted on a spindle which rotates in a stuffing-box on one side-cover of the cylinder; the other side-cover has an axle bolted to it concentric with the paddle-spindle; the necks or journals of both spindles rest in bearings at either side of the cylinder, these bearings forking out from the casing containing the governor-valve, so that valve and governor are all in the same bracket or casing. On the extremity of the axle, which is bolted to the cylinder, is a pinion out beyond the bearing; and beyond the pinion again is a fusee or scroll-wheel to which a weight and chain are attached. The pinion gears into a rack on an arm of a spindle which actuates the valve.

The action of the governor is thus: when the paddle is caused to rotate, it sweeps the oil round with it in a current whose force is proportionate to the speed at which the paddle rotates. The current of oil acts on the projections within the corrugated cylinder, and gives it a certain tendency to rotate also; thus when the governor is at rest, then the weight hanging from the scroll-wheel is down, but as soon as the paddle begins to rotate with any reasonable velocity, then the cylinder is influenced by the current of oil and moves, raising the weight in doing so; owing, however, to the shape of the scroll, the radius and consequently the leverage of the scroll alter rapidly, and the weight acts with ever increasing resistance against the cylinder. As the cylinder moves, so do the pinion and rack, which in turn close or open the valve.

As it is essential that the valve of any governor shall oppose no resistance to the governor's movements, the valve fitted to Allen's governor is in all respects a modification of a common equilibrium valve. The steam enters a chamber which is flat at top and bottom, two seats of suitable size being bored in, within each of which works a valve, the two valves being joined by a tube cast with them; it is evident that the steam pressure on the one valve exactly balances that on the other. The upper valve has a bridge or fitting cast on it, within which the end of the arm of a spindle works, being provided with a small wheel to diminish friction. The spindle passes outside the casing through a stuffing-box and is connected with the rack moved by the pinion.

From the foregoing description it will be evident, that according as the pinion moves the rack so it again will act on the valve and increase or diminish the steam supply. There was one point which appeared defective in this governor which may be thus explained.

The governor of a steam-engine ought more correctly to be termed an equalizer; because it has to maintain the varying loads on the engine on perfect equality with the variations of pressure in the boiler. Now, suppose a certain steam-engine is making one hundred revolutions per minute with a given load, and using a corresponding quantity of steam, then, of course if the load be diminished, say thirty per cent. in that case the steam supply must be diminished also, and the theoretically perfect governor will close the throttle-valve just enough for this, the governor, however, being subservient to the speed of the engine, not to the load on it (a defect in principle, by the way, inherent in all governors) will not alter the supply of steam till the speed of the engine alters first; bearing this then in mind, naturally that form of governor most sensible to the rate of the engine is, *cæteris paribus*, the best. A governor, however, must not alone close the valve if the load on the engine is diminished, but it must keep it closed when the regular speed of the engine is restored; thus, suppose the engine, with a resistance which we will call a hundred, and using a rate of steam which we will also call a hundred, and the lever of the throttle-valve being at an angle with the horizon of thirty degrees, the engine makes one hundred revolutions per minute. Then, suppose the load reduced to seventy, the speed of the engine will increase, and so also will that of the governor, which will then close the throttle-valve by moving the lever from thirty to, let us say twenty-five degrees, the supply of steam is reduced and the engine resumes its true speed of one hundred; but the governor must not now shift back, for of course if it does the engine will again go too fast. The governor must retain the throttle-valve lever at the twenty-five degrees angle, till the load on the engine is altered again, when the governor must likewise shift so as to admit a due proportion of steam. Now, in Allen's governor, as manufactured by Messrs. Whitley Partners of Leeds, the oil-paddle is run at a speed of, say 7 to 1 that of the engine, therefore it is affected seven-fold by any variation that affects the engine, consequently it approaches very near that perfection of action we defined above, when the load ought really to affect the governor and not the engine; therefore, the speed of the engine cannot really alter almost at all, as will be seen by the following description of an engine at Messrs. John Crossley and Sons', Halifax, the speeds being tested by Taylor's speedometer.

Revolutions required to support weight at largest diameter of scroll, 370; ditto ditto at intermediate diameter, 365; ditto ditto at least diameter, 364; variation, six revolutions in three hundred and seventy, equalling 1·62 per cent. Speed of engine, revolutions per minute, 60; variation of engine speed per minute, 0·973 of a revolution. Thus proving at once that this governor is quite free from the defect referred to above, of regulating the supply of steam to the engine by the speed of the engine instead of by the load on it.

This governor is adapted to marine engines by substituting a spring for the weight, and this spring is so fitted with a regulating screw that it can be always adjusted with the utmost nicety; thus the rolling and pitching of a ship in a sea-way cannot in any way vitiate the efficient action of the governor.

Glycerine as an Anti-Incrustator.

THE New York "Iron Age" says:—The manufacture of glycerine has of late, in view of its constantly extending importance in the arts, been greatly expanded. During the past year the production in the United States alone reached 2,000,000 lbs., of which one firm in Cincinnati manufactured one-half. In a communication addressed to the French Society of Civil Engineers, M. Austin has highly recommended the employment of this substance as an anti-incrustator in steam boilers. Glycerine, which is soluble, in all proportions, in water, appears, according to M. Austin, to increase very notably the solubility of the lime salts, to which the evils of incrustations in boilers are mainly ascribable; indeed, according to the author, it really forms with them a soluble compound. When the lime salts accumulate to such an extent as to be no longer soluble in the glycerine present, they are deposited in the form of a gelatinous sediment, which does not adhere to the boiler surface. M. Austin recommends the employment of one pound of glycerine to every 300 or 400 pounds of coal burnt. From actual trials made with the material, it is declared in the communication that the employment of glycerine for this purpose, and in the manner above described, proved successful.